PB87-182226

Compound 1080, Sodium Monofluoroacetate Position Document 2/3

(U.S.) Environmental Protection Agency
Washington, DC

Jun 83

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

REPORT DOCUMENTATION PAGE	**1. REPORT NO.**	**2.**	**3. Recipient's Accession No.** PB87 182226/AS

4. Title and Subtitle

COMPOUND 1080: POSITION DOCUMENT 2/3

5. Report Date June 1983

6.

7. Author(s) EPA, OPP, REGISTRATION DIVISION

8. Performing Organization Rept. No. 540/09-87- 166

9. Performing Organization Name and Address

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDE PROGRAMS
WASHINGTON, D.C. 20460

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address

SAME AS #9

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This Position Document addresses the risks and benefits of pesticide products containing the subject active ingredient. The Agency has determined that the use of products containing the subject active ingredient may meet or exceed a risk criterion described in 40 CFR Part 154. Potential hazards will be examined further to determine the nature and extent of the risk, and considering the benefits of the subject active ingredient, whether such risks cause unreasonable adverse effects on the environment.

17. Document Analysis a. Descriptors

Pesticides, standards, regulations, manufacturing, chemistry, toxicology, residues, ecology, path of pollutants.

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement: Publicly Available	**19. Security Class (This Report)** Unclassified	**21. No. of Pages** 114
	20. Security Class (This Page) Unclassified	**22. Price**

(See ANSI–Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4–77)
(Formerly NTIS–35)
Department of Commerce

EPA-540/09-87-166

PB87-182226

United States
Environmental Protection
Agency

Office of
Pesticides and Toxic Substances
Washington DC 20460

JUNE 1983

EPA

Sodium Monofluoroacetate (Compound 1080)

Position Document No. 2/3

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U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
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SPRINGFIELD, VA 22161

ERRATA SHEET FOR
POSITION DOCUMENT 2/3,
COMPOUND 1080

The following changes in the bound copy of the Sodium Monofluoroacetate (Compound 1080) Position Document No. 2/3 are required.

1. Page 3, paragraph 4. The schedule for requiring submission of applications for Federal registration of intrastate products has been changed. Therefore, the paragraph should read:

> The Agency will be directing intrastate registrants to submit applications and information necessary for Federal registration following the issuance of the Agency's final decision concluding this RPAR proceeding. Applications which do not comply with the terms and conditions of the final decision will be denied.

2. Page 76, paragraph 2. The paragraph beginning "Certain points..." and ending with "...feasible and viable." should be deleted as an imprecise description of the Agency's decision making process.

3. Page 87, paragraph 5. The Agency lacks data to reliably estimate the impact of performing a precontrol survey for black-footed ferrets on the cost of using 1080 for prairie dog control. Accordingly, this paragraph should be revised to read:

> The requirement to conduct a precontrol survey for the endangered species, black-footed ferrets, would obviously raise the cost of using 1080 to control prairie dogs. While available data are not sufficient to allow EPA to estimate the additional cost, it is possible that zinc phosphide might be cheaper to use than 1080, if a precontrol survey is required before 1080 is applied.

Compound 1080 Position Document 2/3

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TABLE OF CONTENTS

Page

I. INTRODUCTION 1
  A. Background 1
    1. The RPAR Process 1
    2. Compound 1080 RPAR 2
    3. Related Federal Actions 3
  B. Compound 1080 3
    1. Physical and Chemical Properties 3
    2. Production 4
    3. Registered Uses 4
    4. Estimated Usage 6
II. REBUTTAL ANALYSIS 8
  A. Background 8
  B. Acute Toxicity to Birds and Mammals 8
  C. Significant Reduction in Populations of Nontarget Species and Fatalities to Members of Endangered Species 9
    1. Population Reduction 10
    2. Endangered Species 11
      a. General 11
      b. The California Condor 11
      c. The San Joaquin Kit Fox 14
    3. Aerial Application 14
  D. Lack of Emergency Treatment 14
III. RISK ANALYSIS 16
  A. Compound 1080 16
    1. Methods of Application for Target Species 16
      a. Ground Squirrels 16
      b. Prairie Dogs 16
      c. Meadow Mice 17
      d. Pocket Gopher 17
      e. Commensal Rodents 17
    2. Toxicology 17
      a. General 17
      b. Acute Toxicity 18
      c. Subacute and Chronic Toxicity 22
      d. Bioaccumulation and Tissue Residues 22
      e. Secondary Toxicity 22
    3. Direct Risks to Nontarget Species 24

Table of Contents (Continued)

Page

4. Indirect Risks to Nontarget Species 25
  a. Coyotes 26
  b. Bobcats 26
  c. Community Level Impacts 27
5. Risks Associated with the Control of Other Rodents 28
6. Relation of Bait Formulations to Risks 28
7. Risks to Members of Endangered Species 33
  a. San Joaquin Kit Fox 34
  b. Black-Footed Ferret 34
  c. California Condor 34
  d. Aleutian Canada Goose 36
8. Human/Domestic Risks 37

B. Alternatives 38

1. Strychnine 38
  a. Methods of Application for Target Species 38
    (1) Ground Squirrels 38
    (2) Prairie Dogs 39
    (3) Kangaroo and Cotton Rats 39
    (4) Pocket Gopher 39
  b. Toxicology 39
    (1) General 39
    (2) Acute Toxicity 40
    (3) Subacute and Chronic Toxicity 43
    (4) Bioaccumulation and Tissue Residues 43
    (5) Secondary Toxicity 43
    (6) Field Data 43
    (7) Summary 43
  c. Human/Domestic Risks 44
2. Zinc Phosphide 44
  a. Methods of Application for Target Species 44
    (1) Ground Squirrels 44
    (2) Prairie Dogs 44
    (3) Meadow Mice 44
  b. Residues 45
  c. Toxicology 45
    (1) General 45
    (2) Acute Toxicity 46
      (a) Laboratory Data 46
      (b) Field Studies 46
    (3) Secondary Toxicity 48
  d. Human Risks 48
3. Anticoagulants 48
  a. Methods of Application for Target Species 48
  b. Toxicology 49
    (1) CPN 49
    (2) DPN 49
    (3) Other Anticoagulants 50

Table of Contents (Continued)

Page

c. Human Risks 50
(1) CPN 50
(2) DPN 50
(3) Other Anticoagulants 51
4. Fumigants 51
a. Methods of Application for Target Species 51
b. Toxicology and Risks 52
c. Other Fumigants 52
5. Repellents 52
6. Relative Risks and Comparative Data 53
7. Summary 56

IV. Benefit Analysis 58

A. Introduction and Summary 58

B. General Production and Use Patterns 59

C. Analysis of Benefits of Compound 1080 Use on Agricultural Sites 62

1. Rangelands 62
a. Ground Squirrels 62
b. Prairie Dogs 66
c. Miscellaneous Rodents 68
2. Croplands 68
a. Ground Squirrels 69
b. Meadow Mice 69
c. Prairie Dogs 71
d. Miscellaneous Rodents 71

D. Analysis of Benefits of Compound 1080 Use on Nonagricultural Sites 74

1. Federally Registered Uses 74
2. State Registered Uses 75

V. Risk/Benefit Analysis and Regulatory Options 76

A. General 76

B. Risk/Benefit Analysis 76

1. Rangeland Rodents 76
2. Cropland Rodents 78
3. Nonagricultural Site Rodents 78

Table of Contents (Continued)

Page

C. Regulatory Options 78

1. General 78
   a. Bait Formulations 79
   b. Application Procedures 80
   c. Temporal Restrictions 80
   d. Geographic Restrictions 80
   e. Integrated Pest Management 81
2. Rangeland Rodents - ground squirrels 81
3. Rangeland Rodents - prairie dogs 86
4. Rangeland Rodents - other rodents 87
5. Cropland Rodents - ground squirrels 89
6. Cropland Rodents - prairie dogs 90
7. Cropland Rodents - other rodents 90
8. Rodents on Nonagricultural Sites 90

D. Proposed Actions 91

1. Rangeland Rodents - ground squirrels 92
2. Rangeland Rodents - prairie dogs 94
3. Rangeland Rodents - other rodents 95
4. Cropland Rodents - ground squirrels 95
5. Cropland Rodents - prairie dogs 96
6. Cropland Rodents - other rodents 96
7. Rodents on Nonagricultural Sites 96

E. Summary 97

List of Tables

Table	Title	Page
I-1	Compound 1080, Federal-State Registrations	5
I-2	Percentage of Use by Site/Pest Combination and by State	7
III-1	Acute Oral Toxicity of Compound 1080	19
III-2	Toxicity of Various Compound 1080 Grain Formulations	30
III-3	Number of Squirrels that Consumed 200 Kernels (4.5 g) of Compound 1080 Bait Required to Produce a Carnivore LD_{50}, Assuming 75 Percent Detoxification	32
III-4	Acute Oral Toxicity of Strychnine Alkaloid	41
III-5	Acute Oral Toxicity of Zinc Phosphide	47
III-6	Relative Risks of Alternative Toxicants	54
IV-1	Summary: Estimated Economic Impact of cancelling Compound 1080	60
IV-2	Estimated Annual Usage of Compound 1080 Bait for Rodent Control, 1977-78	61
IV-3	Chemical Alternatives to Compound 1080	63
IV-4	Estimated Economic Impact of Cancelling Compound 1080 for Ground Squirrel Control Rangeland, 1979	65
IV-5	Estimated Economic Impact of Cancelling Compound 1080 for Prairie Dog Control on Colorado Rangeland, 1979	67
IV-6	Estimated Economic Impact of Cancelling Compound 1080 for Ground Squirrel Control on Cropland, 1979	70
IV-7	Estimated Economic Impact of Cancelling Compound 1080 for Prairie Dog and Meadow Mouse Control onCropland, 1979	72

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Appendices

Appendix	Title
A	Compound 1080, Position Document 1 and RPAR Notice, December 1, 1976
B	List of Rebutters.
C	Rebuttal Analysis.
D	USDI Fish and Wildlife Service Endangered Species Report.
E	Preliminary Benefit Analysis.

I. INTRODUCTION

A. Background

1. The RPAR Process

Through the Federal Insecticide, Fungicide and Rodenticide Act as Amended (FIFRA), the United States Environmental Protection Agency (EPA) has the authority for regulating the use of pesticides. This authority includes the registration, reregistration, and classification of pesticides. The process for administering this authority provides, by regulation, for the identification of pesticides that appear to cause unreasonable adverse effects on human health and the environment.

Under this process, each pesticide and its metabolites or degradation products is evaluated for its potential to meet or exceed any of certain risk criteria. The three general risk criteria (acute toxicity, chronic toxicity, and lack of emergency treatment) are described in 40 CFR 162.11. If the Agency's evaluation of a pesticide, from available information, indicated that the potential for unreasonable adverse effects exists, a notice of rebuttable presumption against registration and continued registration (RPAR) is published in the Federal Register. The notice explains the reasons for the presumption(s) and provides an opportunity for registrants, applicants, and other interested parties to rebut or support the presumption.

EPA examines the rebuttals and the supporting evidence to determine if the original presumption(s) are still valid. If the rebuttal analysis results in a conclusion that one or more of the criteria is met or exceeded, a complete risk assessment is performed. This assessment documents the risks associated with the use(s) of the pesticide, methods for reducing or eliminating these risks, and the risks associated with the substitution of alternatives. A benefit analysis of the use(s) of the pesticide is also performed. The principal concern in the benefit analysis is an assessment of the economic impacts on pesticide users and on the consumers of the user's products. The benefit analysis identifies the major and minor uses of the pesticide and the registered alternative products. A determination is made of the change in costs for treatment with available substitute products. The regulatory impact on use productivity, in terms of yield per acre or total output, is assessed. Also, the impact on major agricultural commodities and retail food prices, should the uses of the pesticide be cancelled, is assessed.

A comparison of the risks and benefits of each use is made and available regulatory options are developed. The impact on the risks and benefits is evaluated for each regulatory option. During this period, the registrants are contacted to discuss possible regulatory options, and to clarify existing use patterns. The final Agency decision is based upon achieving the goal of a pesticide performing its intended function without causing unreasonable adverse effects on the environment. Thus, the Agency attempts to determine the regulatory position at which benefits exceed risks and at which further risk reduction is not appropriate given the corresponding benefit reduction which could occur.

2. Compound 1080 RPAR

The RPAR notice for compound 1080 (sodium fluoroacetate or sodium monofluoroacetate) was published in the Federal Register of December 1, 1976 (41 FR 52792). The presumption was against all pesticide products containing compound 1080. At the time of the RPAR, only rodenticide uses were registered. The predator control uses had been cancelled by the Agency in 1972. The RPAR criteria that were determined to have been met or exceeded for the uses of compound 1080 are: 1) acute toxicity to mammals and birds, 2) significant reduction in populations of nontarget organisms and fatalities to members of endangered species, and 3) lack of emergency treatment. The reasons for the determination were explained in detail in the RPAR notice and accompanying Position Document (PD) 1 (Appendix A). The following paragraphs summarize the information available at the time the PD 1 was issued.

The acute toxicity criterion was based on a determination that nontarget mammals and birds are likely to consume lethal quantities of compound 1080 bait. A lethal quantity could be consumed directly by eating the bait, or indirectly by eating an organism poisoned by compound 1080. Compound 1080 LD_{50} values were not, and are not, available for many of the suspected affected nontarget species. Risk to such nontarget species was based on available LD_{50} values of target and nontarget species of the same genus as those for which LD_{50} values were unavailable.

The rationale, for determining that the significant reduction in nontarget organism populations criterion was met, was based on acute oral toxicity data. These data suggested that a risk to nontarget species, through direct ingestion of compound 1080 treated bait, could reasonably be expected.

The criterion for endangered species was based on a laboratory study that demonstrated a hazard to the endangered San Joaquin kit fox from secondary poisoning. In this study, a kangaroo rat was killed with a quantity of compound 1080 that could be consumed by the rat by ingesting grain bait treated with compound 1080. A desert kit fox, a subspecies of kit fox related to the endangered San Joaquin kit fox, was fatally poisoned by eating the kangaroo rat.

The lack of emergency human treatment criterion was based on the following reasons:

- once a fatal dose of compound 1080 is absorbed into the blood stream, the victim will inevitably die.
- symptoms of compound 1080 poisoning may not occur until after a total fatal dose has been absorbed into the blood stream.
- current compound 1080 labels do not specifically prohibit use around domestic dwellings where exposure to children is likely; and
- monoacetin, the potentially most effective medication for compound 1080 poisoning, is not available in a pharmaceutical grade.

3. Related Federal Actions

Several other actions by the Federal government involving compound 1080 should be noted. In March of 1972, Executive Order 11643 was issued. The purpose of this order was to restrict, on Federal lands or in Federal programs, the use of chemical toxicants for predator control and all uses of chemical toxicants which have secondary poisoning effects. Executive Order 11643, as amended, was revoked on February 27, 1982.

This order was amended in July of 1975 by Executive Order 11870 which placed the restriction on the use of those chemical toxicants in predator control programs which would have secondary poisoning effects. Also in March of 1972, EPA cancelled the registrations of thallium sulfate, cyanide, strychnine, and compound 1080 for predator control. The decision was based on a determination that an imminent hazard existed to nontarget animals. Additionally, in February 1978, EPA restricted use of several pesticides, including all compound 1080 solutions and dry baits, for use only by certified applicators (43 FR 5791). The criteria influencing the restriction for compound 1080 were acute oral toxicity, hazards to nontarget species, and use and accident history.

As a result of a request from the National Wool Growers Association and the National Cattlemen's Association, the Agency held hearings on July 28, 29, and 31, 1981, to determine whether significant new evidence existed which would warrant formal hearings to reconsider the 1972 cancellation order. The Administrator made the decision that sufficient new evidence was presented at the July hearings and through other communication to warrent administrative hearings. Those hearings were completed on August 6, 1982. The hearings were concerned only with the predicide uses of compound 1080 and do not affect this RPAR. However, any relevant data introduced during the hearings will be used in developing the final RPAR decision.

The Agency will be directing intrastate registrants to submit applications and information necessary for Federal registration. The information submitted will be reviewed together with the comments received on this position document and used to arrive at a final Agency position. The applications will be considered as pending and can be amended to comply with the provisions in the final position document.

B. Compound 1080

1. Physical and Chemical Properties

Sodium monofluoroacetate, or compound 1080, is prepared synthetically, although monofluoroacetic acid occurs naturally in several poisonous plants found in Africa, Australia, and Brazil. Compound 1080 is a white, powdery material, having no odor and only a mild salty, sour taste. It is hygroscopic, highly soluble in water, and relatively insoluble in organic solvents and animals fats and oils.

Compound 1080 is unstable at temperatures above 110 degrees centigrade and decomposes at 200 degrees centigrade.

Compound 1080 is apparently distributed uniformly throughout the tissues and organs within a few hours after ingestion.

Animals can metabolize compound 1080, and excrete both the poison and its metabolites. Compound 1080 appears to accumulate in some animals. Sodium monofluoroacetate is degraded in the soil by decomposer organisms and in plants by enzymes.

2. Production

Tull Chemical, in Oxford, Alabama, is the sole U.S. producer of compound 1080 and therefore the figures for production are considered proprietary information. It is not imported and exports are estimated to be about 20 to 40 percent of domestic production.

3. Registered Uses

Only one compound 1080 product is federally registered. This product is used only by bonded professional applicators for the control of the Norway rat, roof rat, and house mouse in buildings, ships, warehouses, and homes. In addition, there are 50 products which have intrastate registra-tions (46 in California, three in Nevada, one in Colorado) and one registered in Oregon under section 24(c) of FIFRA.

Compound 1080 is registered in four states (California, Colorado, Oregon and Nevada) for the control of ground squirrels on agricultural sites. Other uses for which compound 1080 is registered include the control of prairie dogs in Colorado, meadow mice in California, Colorado, and Nevada, and pocket gophers in California and Nevada. Table I-1 is a summary of the registered uses of compound 1080 derived from label information and discussions with state and county officials.

For purposes of analysis, the uses of compound 1080 have been grouped into the following three site/pest categories:

a. Rangeland/pasture rodents:

sites - rangeland, pasture, and fallow
pests - ground squirrels, prairie dogs, deer mice, meadow mice, kangaroo rat, cotton rat, chipmunks, and pocket gophers.

b. Cropland rodents:

sites - field crops such as grains and forages and horticultural crops such as nuts, fruits, and vegetables
pests - ground squirrels, prairie dogs, meadow mice, cotton rat, wood rat, Norway rat, and pocket gopher.

Table I-1

Compound 1080, Federal-State Registrations

Pest	Major Use Sites				
	Agricultural		Nonagricultural		
	Cash crops including orchards	Range, Pasture, Fallow	Forests, reforestation areas, tree plantations	Buildings, ships, warehouses and homes 1/	Non-Crop 2/
Ground Squirrels	Ca.; Co.; Nv.; Or.	Ca.; Co.; Nv.; Or.			Ca.; Nv.
Chipmunks		Nv.			Nv.
Prairie Dogs	Co.	Co.			
Norway Rat	Ca.			F	Ca.
Roof Rat				F	Ca.
Cotton Rat	Ca.; Nv.	Nv.			Ca.; Nv.
Kangaroo Rat		Ca.			Nv.
Wood Rat	Ca.		Ca.		
Deer Mice		Nv.	Ca.		
Meadow Mice	Ca.; Co.	Ca.; Co.; Nv.			Ca.; Co.; Nv.
House Mouse				F	
Pocket Gopher	Ca.; Nv.	Ca.; Nv.			Ca.; Nv.

1/ Includes adjacent areas. Not to be used inside occupied premises; outside placements must be made in bait boxes or deeply into burrows.

2/ Includes golf courses, parks, cemeteries, athletic fields, airport runways, ditch and canal banks, earthen dams, levees, and dumps.

F: Federally registered

Source: Federal Registration
State Registrations
State Agencies:
California Department of Food and Agriculture
Colorado Department of Agriculture
Nevada Department of Agriculture

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c. Nonagricultural site rodents:

sites - grain elevators, other crop storage areas and facilities, commercial buildings and warehouses, open dumps, farmsteads, urban dwellings, ditch banks, levees, dikes, canals, earthen dams, golf courses, parks, cemeteries, athletic fields, recreational areas, airport runways, tree nurseries, tree plantations and reforestation areas.

pests - chipmunks, pocket gopher, ground squirrels, wood rat, kangaroo rat, cotton rat, deer mice, meadow mice, house mouse, Norway rat, and roof rat.

4. Estimated Usage

Estimated annual usage of compound 1080 bait was 610,600 pounds for 1977-1978. Seventy-four percent was used for ground squirrels and prairie dogs on rangelands, 21 percent for cropland rodents, and five percent for nonagricultural sites.

By pest, ground squirrel control accounted for approximately 75 percent of the bait, prairie dogs another seven percent and other rodents 18 percent. By state, California used 83 percent, Colorado 12 percent, and other states five percent. No figures are available for usage in Oregon, as the product was registered in July, 1981.

The percentage of use of each site/pest combination and by state is shown in Table I-2.

Table I-2

Percentage of Use by Site/Pest Combination and by State

Site

Pest	Rangeland/Pasture	Cropland	Nonagricultural	Total
Ground Squirrels	CA - 66% CO - 1%	CA - 4% CO - 4%	-	CA - 70% CO - 5%
Prairie Dogs	CO - 6%	CO - 1%	-	CO - 7%
Other Rodents	CA - 0.5%	CA - 12.5%	U.S. - 5%	CA - 13% U.S. - 5%
Total	CA - 66.5% CO - 7%	CA - 16.5% CO - 5%	U.S. - 5%	CA - 83% CO - 12% U.S. - 5%

II. REBUTTAL ANALYSIS

A. Background

Registrants and other interested parties were offered an opportunity to review the data upon which the RPAR against compound 1080 was based and to submit information to rebut the presumptions. Respondents could rebut the presumption by showing that the Agency's initial determination of risk was in error or by showing that common use patterns and actual exposure indicate that use of the pesticide is not likely to result in any significant adverse effects (40 CFR 162.11(a)(4)(i), (ii), (iii)).

Registrants and other interested persons were also offered the opportunity to submit evidence as to whether the economic, social, and environmental benefits of continuing to use this pesticide outweigh the risks of its use (40 CFR 162.11(a)(5)(iii)). Comments addressing the benefits of compound 1080 are considered in Section IV of this document.

The Agency received 68 rebuttal submissions in response to the RPAR on compound 1080. No scientific data were submitted to support the majority of the comments received. Moreover, the limited scientific data submitted were either insufficient or contained inadequate test methods to support the position taken. Significant comments and the Agency's responses are presented in this Section. The complete analysis of the rebuttal submissions is contained in Appendix C.

B. Acute Toxicity to Birds and Mammals

Sections 40 CFR 162.11 (a)(3)(i)(B)(1) and (2) provide that a rebuttable presumption against registration shall arise if the pesticide occurs as a residue immediately following application in or on the feed of a mammalian or avian species representative of species likely to be exposed to such feed in amounts equivalent to the average daily intake of such species at levels equal to or greater than (1) the acute oral LD_{50} for mammalian species or (2) the subacute dietary LC_{50} for avian species.

In its presumption that nontarget wildlife would be at risk from the use of compound 1080 bait, the Agency noted that toxicity data were not available for many species at risk but that (1) there is a narrow range of LD_{50} values for compound 1080 among birds and mammals tested (0.05 mg/kg for nutria to 20.0 mg/kg for turkey vultures; those of most mammals and birds tested range from 0.1 to 6.0 mg/kg), and (2) species of the same genera [sic] are biologically similar. Calculations were then used to demonstrate that several nontarget, nonpest relatives of pest species would be at risk if they were present in an area treated to control a pest species.

In response to the Agency's analysis of acute toxicity, respondents (30000/8: #52 and 63) challenged the assertion that compound 1080 has a narrow range of toxicity, citing a compilation of toxicity values by Atzert (1971). Additionally, respondent 30000/8: #36 stated, "It is our argument that the criterion 'use patterns' is the driving force in the Agency's position of hazard to wildlife and also our argument that the criterion of 'use patterns' is a control label factor and does not fit into the presumption of hazard to wildlife due solely to acute toxicity . . . . It is therefore our contention that the Agency has injected into its presumption of Acute Toxicity: Hazard to Wildlife a criterion which is not valid to the argument and without which the Agency's conclusions that . . . acutely lethal residues . . . will be available to expose nontarget species' or that '. . . the same toxic properties . . . will . . . cause the deaths of nontarget organisms' cannot be supported". Similarly, several respondents (30000:8 #4, #6, #8, #11, #41, #47, #52, and #54) claimed that no hazard existed to wildlife with commensal rodent control in and around such sites as feed mills, poultry houses, unoccupied structures, homes, urban areas, and dumps.

The Agency agrees that its characterization of the toxicity range for compound 1080 as "narrow" was inappropriate. A 1000-fold difference apparently exists between the oral LD_{50}'s (0.056 mg/kg) for nutria (Myocastor coypus) and 60.0 mg/kg for the opossum (Didelphis marsupialis). The Agency also acknowledges that for some nontarget mammalian and avian species, compound 1080 is significantly less toxic than for species similar to target species; however, compound 1080 is generally more toxic to canine and feline species than to the target species (Table III-1). Therefore, while the original presumption might not have been entirely accurate for all nontarget species, it can reasonably be concluded that some nontarget species are as susceptible to compound 1080 as the target species and the presumption is not rebutted solely by its lack of precision on this point. This will be explored further in Section III for specific nontarget species.

The Agency also agrees that comparative toxicity alone does not serve as a valid presumption of risk and that use patterns, as they affect exposure, are relevant. Respondents have not demonstrated, however, that exposure to all susceptible species is precluded by existing directions for use. Therefore, the presumption is not rebutted on this point. However, use patterns and exposure will be weighed in assessing risks and developing regulatory options.

C. Significant Reduction in Populations of Nontarget Organisms and Fatalities to Members of Endangered Species

40 CFR Section 162.11 (a)(3)(ii)(C) provides: "A rebuttable presumption shall arise if a pesticide's ingredients . . . [c]an reasonably be anticipated to result in significant local, regional, or national population reductions in nontarget organisms, or fatality to members of an endangered species." In determining that this criterion had been met, the Agency stated, "Although the Agency currently lacks conclusive field studies which demonstrate that use of [compound] 1080 . . . will cause reduction in nontarget organisms or fatalities to endangered species, the [Agency] concluded that these effects can reasonably be anticipated based on:

- Extreme toxicity of [compound] 1080 . . . to vertebrates,
- Current use in areas known to be inhabited by endangered species,
- Aerial broadcast of poisoned bait."

The Agency cited a study by Schitoskey (1975) in which a kit fox related to the endangered San Joaquin kit fox was fed a kangaroo rat containing 0.74 mg compound 1080 — an amount that could have been obtained by feeding on bait. Based on the death of the kit fox, it was concluded that the use of compound 1080 to control rodents in the range of the San Joaquin kit fox could cause fatalities to this endangered species from secondary poisoning.

1. Population Reduction

The major thrust of comments regarding population reductions of nontarget organisms was to point to the absence of evidence from the field and to attribute much of the apparent lack of hazard to game birds to the use of dye on the baits.

The Agency agrees that, if large numbers of nontarget game birds and mammals frequently died in exposed situations in treated areas, the reported efforts spent in monitoring treated areas would probably have detected such effects. Since it is frequently indicated that only a small fraction of the ground squirrels killed by compound 1080 die on the surface, it is equally reasonable to expect that, were nontarget organisms to be killed, many of these would also perish in places where their discovery would be difficult.

In one of the few reports containing data (Marsh, 1968), trapping results suggested that the reduction of deer mice on rangelands where ground squirrels were baited by aircraft with compound 1080 was equal to or greater than that of ground squirrels. Dead jackrabbits, cottontails, kangaroo rats, and wood rats were found but the extent of population reduction was not quantified. The Agency can reasonably accept as accurate that no detectable loss to game birds was observed in this case. It has no basis, however, for believing that the rodents and lagomorphs in general were not subjected to heavy mortality. Hypotheses must remain as hypotheses until appropriate testing can be done to develop data.

In connection with the strychnine RPAR (EPA, 1980), the Agency reviewed the evidence pertaining to the use of dyed baits to deter feeding by birds and concluded that, while there was some evidence suggesting a reduction in risk to birds from the use of dyes, there was no way to predict the degree of such reduction. While it may be, as respondents contend, that the conventional use of dyes on compound 1080 bait provides protection to most birds, the facts that the bait is often persistent, that the dye fades markedly on exposure to the environment (Hegdal et al., 1977a), and that monitoring normally does not take into account this potential lag in exposure, detract from the validity of this claim.

In conclusion, while the Agency agrees that not all species are equally vulnerable to the use of 1080 to control ground squirrels, respondents have provided no data that would alleviate the Agency's concerns over those species that, a priori, would appear to be most vulnerable, namely, other rodents, lagomorphs and carnivores. Thus, the presumption has not been rebutted. Subsequent to issuing the RPAR, a monitoring study by Hegdal et al. (1979) has been received. This study is reviewed in Section III.

2. Endangered Species

a. General

One respondent (30000/8: #46) challenged that the "whole endangered species concept with regard to pesticides needs review." His argument had two basic points:

(1) The basis for most endangered species' problems is competition with humans for space and life support needs.

(2) The designation of a small portion of a large group as an endangered species is a "taxonomic technicality."

The elimination of habitat and competition with humans are indeed major factors for reduced populations of many species and especially some endangered species. The Agency does not need to demonstrate that compound 1080 is the reason that endangered species have attained that status, but EPA has indicated that compound 1080 is a possible source of mortality further endangering those species. The burden of proof that compound 1080 is not hazardous to those species is the responsibility of the party seeking new or continued registration.

The authority for the designation of endangered species rests with the Department of the Interior, Fish and Wildlife Service, Office of Endangered Species. EPA accepts the species designations of the lead agency.

b. The California Condor

Comments and documents alleging that the condor was not at risk from the use of compound 1080 to control ground squirrels made two points: that there is no record of any condor being killed by compound 1080 and that the number of squirrels that a condor would have to eat before being poisoned is ludicrously large. Neither of these arguments, as presented, serve to rebut the presumption.

The absence of a confirmed fatality carries little weight for several reasons. Compound 1080 is a slow-acting poison and, were a condor to be poisoned, it would likely succumb in an area remote from the control operation and probably not be found. Condors have become so rare that very few specimens of dead birds are likely to be available for analysis. Respondents (30000/8: #52) indicated only one of two dead condors had actually been analyzed for compound 1080 and did not indicate what analytical procedures were used to evaluate the presence of compound 1080, or what criteria might be used to determine whether compound 1080 was the probable cause of death. In the absence of such an evaluation, the Agency is not persuaded that the absence of evidence is proof of no risk.

Hagen (1972) reported that, "The only condor carcass we have had access to was one that was killed by flying into a power transmission line in 1965. Its digestive tract was analyzed and 1080 residues were found. There was no indication that 1080 contributed to the bird's death." Hagen did not indicate how one could conclude that the condor's faculties were not impaired by the compound 1080, nor did he indicate how the condor may have come in contact with compound 1080.

Documents submitted to rebut the risk to the condor on theoretical grounds are generally deficient in their analysis. While Koford (1953) is properly quoted as concluding that" . . . a turkey vulture would have to eat as much as 40 times its own weight in poisoned squirrels before it would probably be killed", his next sentence is ignored: "The amount would be less if the contents of cheek pouches and stomach were eaten or if the squirrel had ingested more than the minimum lethal dose." Respondents (30000/8: #36, #46 and #52) referenced a report by Roest (1970) describing subchronic feeding of compound 1080-poisoned ground squirrels to a turkey vulture (Cathartes aura). Thirty poisoned squirrels were fed to the vulture at a rate of about one per day for 32 days with no adverse effect. The application of this study to demonstrate the safety of compound 1080 in the range of the endangered California condor (Gymogyps californianus) is inconclusive for two major reasons. First, while the turkey vulture and the California condor are similar in that they are carrion feeders and belong to the same family, Cathartidae, they are of different genera. As such, their susceptibility to compound 1080 may or may not be similar. No scientific evidence has been submitted to demonstrate similar LD_{50} levels.

Second, no data were presented concerning the amount of compound 1080 present in the poisoned ground squirrels. In fact, the amount of compound 1080 consumed by the turkey vulture is unknown, since the vulture did not eat the whole ground squirrel with its concentration of compound 1080 in the cheek pouches, stomach, and intestines. Roest (1970) commented that, "It is important to point out that in feeding, the head of the squirrel (with the cheek pouches) and the intestinal tract were never eaten. The vulture seemed to feed almost exclusively on muscle tissue, which was carefully removed from the bone, and also ate the heart, liver, kidneys, etc. The head, stomach, and intestinal tract were never eaten."

While Sibley (1966) states, "In fact Koford (page 58) remarks that the stomach and intestine are usually left uneaten by Turkey Vultures and Condors", Koford's actual observations bear reporting:

> "With the occasional exception of the intestine and stomach, all viscera are usually missing from carcasses on which condors have fed. Among the scattered remains of one sheep I found the intestine, fairly intact. The intestinal contents remain in the abdominal cavity of the carasses of large cattle.

> "One day I flushed five condors from the remains of two ground squirrels on which they had been feeding. The caecum and much of the intestine of both squirrels were among the parts which were scattered for 20 feet.... The skulls were fairly well cleaned, and they were unbroken except for the one zygomatic arch. There was little left of the wet shredded skin.... Once I saw a golden eagle, and another time a turkey vulture eat the carcass of a poisoned squirrel and leave the stomach and part of the intestine. Joseph Keyes of the Fish and Wildlife Service told me that this is a common habit of condors and turkey vultures.
>
> "Casts and pellets. -- In every condor nest that I entered I found bones or bone fragments and other indigestible parts of mammals on which condors had fed. Some of these items, and their maximum dimensions (in millimeters) measured at right angles to each other, are listed below:
>
> | | |
> |---|---|
> | Tarsal or carpal of cow (*Bos*) | 43 x 30 x 25 |
> | Epiphysis of long bone | 50 x 40 x 4 |
> | ... | |
> | Sheath of hoof of calf, entire | 50 x 30 x 13 |
> | Skull of ground squirrel (*Citellus beecheyi*) | 50 x 30 x 18 |
> | Section of hide (horse?) | 65 x 65 |
> | Tip of ear of fawn, hair complete | 100 x 35 |
>
> "I collected about 300 of these castings in and below condor nests. Dr. R. A. Stirton kindly examined this collection and found that practically all the identifiable bones were of cattle, although horse, sheep, deer, jack rabbit, and ground squirrel were represented. The bones were clean of flesh and showed no evidence of corrosion by digestive fluids . . . . Only two pieces of heavy hide were found. Some small and rather delicate bones, such as the lower jaw of a ground squirrel and the upper jaw of a jack rabbit, were unbroken and still held all their teeth. In the stomach of a South American condor Murphy (1925:190) found a hoof and a few bristles of a pig, two leg bones and some cartilages of a seal, and bits of kelp as well as 10 large pebbles. Coles (1944:227) investigated many nest caves of turkey vultures but found no bones or animal remains in them."

Condors, in contrast to vultures, are apparently not particularly delicate feeders, especially perhaps when they are hungry. There is nothing in Koford's account that rules out the possibility that condors may feed on the contents of stomach and cheek pouches of poisoned squirrels although there is nothing to suggest that these items would be fed on selectively. Thus, the submissions are deficient and do not constitute a rebuttal.

c. The San Joaquin Kit Fox

Comments regarding the kit fox relied mainly on the results of studies by Swick (1973) and Morrell (1975) to reach the conclusion that the use of compound 1080 for ground squirrel control did not threaten the survival of the species and that there were no confirmed cases of individual kit fox deaths from the use of compound 1080. While many of the details of the studies will be discussed more appropriately in Section III, the following quotations from submitted documents directly affect the rebuttal analysis:

> "The San Luis Obispo County Department of Agriculture contended that their 1080 ground squirrel control programs had not shown any significant effect on the kit fox population for the past 25 years, but they recognized that individual kit foxes were occasionally lost due to poisoning programs . . . Before the hazard to kit foxes can be satisfactorily assessed more investigation is needed. (Swick, 1973).
>
> "The effect on the kit fox of rodent control programs is uncertain . . . field evaluations have indicated that ground squirrels frequently consume several lethal doses of compound 1080 treated grain bait before death occurs (Swick, 1973b). It is known that a San Joaquin kit fox in the wild will eat carrion, including ground squirrels (Laughrin, 1970; Morrell, 1971, 1972) . . . . The available data indicate that present rodent control programs using compound 1080 treated grain baits may kill some kit fox, but such programs do not constitute a threat to the total San Joaquin kit fox population. (Morrell 1975)."

Since the Agency's risk criterion dealt with fatalities to individuals and since field investigators believe that individual kit foxes are probably killed, the submissions do not constitute a rebuttal of the presumption. The Agency will more fully assess the risks below and consider California's program to protect the kit fox in formulating regulatory options.

3. Aerial Application

The Agency concluded in the PD 1 that adverse effects on wildlife could be anticipated because poisoned bait may be broadcast by air. Respondents failed, however, to challenge the assumption specifically and it stands unrebutted. The issue will be discussed further in the Risk Assessment.

D. Lack of Emergency Treatment

The comments cite the successful use of several antidotes to compound 1080 poisoning. Monoacetin (Chenowith et al, 1951), acetic acid (Tourtellotte and Coon, 1951), acetamide (Gitter, 1956), and ethanol (Hutchens et al., 1948) have all exhibited antidotal properties. An example is a three year-old child hospitalized in a comatose and convulsing condition eighteen hours after accidental ingestion of an unknown quantity of compound 1080-treated grain (30000/8:#52). In the absence of pharmaceutical grade monoacetin, recommended by a poison control center, the patient was administered acetamide intravenously. Complete recovery was observed 72 hours after antidotal therapy was instituted.

The Agency accepts that compound 1080 poisoning can be treated with first aid measures and/or medication. Treatment is dependent, however, on early recognition of symptoms, the quantity of poison ingested, the availability of an emergency treatment center, and the type of medication available.

None of the respondents have demonstrated the effectiveness of any of the antidotal agents following ingestion of a known lethal dose of compound 1080. Although this criterion has not been rebutted, the Agency will consider, in Sections III and V, the accident records, potential for exposure, and the effectiveness of available treatment methods.

III. RISK ANALYSIS

The risk analysis is a detailed study of the risks associated with the registered uses of the RPAR chemical. The specific risks examined are those for which the RPAR notice was issued. In the case of compound 1080, the focus of the analysis is the risk to nontarget birds and mammals, including members of endangered species, from both direct and indirect exposure to treated bait. Human risks associated with the use of compound 1080 and alternatives are examined also.

The approach taken is to first present the common methods of baiting for various target mammals. This information will form the background for the subsequent analysis of the risks to nontarget species. Next, acute and chronic toxicity data, from laboratory and field studies, are presented. The data are for both target and nontarget organisms, and form the basis for the assessment of the risks associated with the baiting practices.

The same approach is used in analyzing the risks of the various alternatives. The alternatives examined are those that are currently registered for the same uses as compound 1080.

Following the analysis of the risks of using compound 1080 and the alternatives, the relative risks are assessed and summarized for each use pattern.

A. Compound 1080

1. Methods of Application for Target Species

a. Ground Squirrels

Sodium fluoroacetate (compound 1080) is used in California, Nevada, Colorado, and Oregon for ground squirrel control as a spot bait on bare ground near burrows. It is also ground applied by mechanical broadcaster or aerially applied in approximately 30-foot-wide swaths. The baits are usually made with oat groats, barley grain, chopped cabbage, or chopped dandelion greens. The concentration of compound 1080 in the various baits ranges from 0.05 percent to 0.12 percent. When applied by hand, baiting is most often accomplished by scattering a teaspoon or a tablespoon of bait over two to three square feet of bare ground near each active burrow. When applied by air or by mechanical broadcaster, about five to six pounds of grain bait or five to ten pounds of cabbage bait per swath-acre are used. Bait applications are usually administered in the late spring.

b. Prairie Dogs

Only one state (Colorado) has a registration for compound 1080 for prairie dog control. The concentration of active ingredient (A.I.) in this oat grain bait is 0.11 percent. An unspecified amount is scattered near burrows over approximately three-square-foot areas (according to use directions printed on the label) by hand, from horseback or terrain cycle.

c. Meadow Mice (Microtus)

Although California, Colorado, and Nevada have intrastate registrations for compound 1080 for control of meadow mice, usage outside of California is negligible at present. In California, bait concentrations for this use range from 0.02 percent A.I. (where 20 percent of the bait material contains a 0.1 percent concentration of compound 1080) to 0.11 percent A.I. Oat groats are used as bait material. Bait is hand broadcast at the rate of about one tablespoon scattered over two or three square feet, or (more often) applied by mechanical broadcaster at four to five pounds per swath acre or by air at approximately six pounds per swath acre.

d. Pocket Gopher

California and Nevada have compound 1080 registrations for pocket gopher control which range in concentration from 0.05 percent A.I. to 0.1 percent A.I. The grain (including whole wheat, oat groats, milo, whole or hulled barley, or cracked corn) baits are hand-placed into burrows through holes opened by a probe, or deposited into intersecting man-made burrows by mechanical burrow-builder. Doses of approximately one tablespoon are inserted by hand into two or more holes in each runway, which are subsequently closed over or, more commonly, bait deposits are made at 9 to 12 inch intervals in man-made burrows by mechanical burrow builder, at the rate of one to two pounds bait per acre.

e. Commensal Rodents

One federally registered compound 1080 product exists (90 percent A.I.) for use primarily against Norway and roof rats, although it is also registered for use against the house mouse. It is usually mixed with water for use as a liquid bait for controlling rats that are relatively permanent inhabitants when food but insufficient water exists, although the product may be incorporated into solid food bait for certain hard to control rodents. Compound 1080 cannot be used inside occupied premises because of its hazard potential to humans.

2. Toxicology

a. General

Compound 1080 is essentially colorless, odorless, and nearly tasteless (Atzert, 1971). The onset of signs and symptoms of poisoning generally occur after a delay period which could allow ingestion of a complete meal containing the toxicant before effects were evidenced. Regurgitation is not commonly induced by compound 1080. For these reasons bait acceptance is usually excellent.

Because the LD_{50}'s by intravenous and oral routes are usually similar, it can be inferred that compound 1080 is well absorbed from the gastrointestinal tract. Gal et al. (1961) determined by radioisotope tracer technique upon rats that intraperitoneally administered compound 1080 was rather evenly distributed in the animal four hours post administration. Little had been expired as $^{14}CO_2$ or excreted in the urine. Following ingestion and absorption, compound 1080 may be metabolized to [-]fluorocitrate intracellularly and this compound is considered to be responsible for the toxic effects (Kun, 1979). The relative amounts of compound 1080 metabolized, unaltered, or excreted must vary substantially depending on the species, dose, and time after ingestion.

Signs and symptoms of compound 1080 poisoning vary. However, they may be classified into three categories: CNS (central nervous system), cardiac, and depression syndromes. The CNS syndrome is characterized by hyperactivity, phonation, tonic spasms and convulsions which lead to respiratory paralysis. The cardiac syndrome is associated with blanching of the retina, muscular weakness, clonic convulsions, and ventricular fibrillation. The depression syndrome is associated with decreased activity, respiratory depression and bradycardia. Additionally, muscarinic effects are produced in certain species of terrestrial wildlife such as ferrets. The time before the onset of symptoms of poisoning almost always exceeds 1/4 hour and death most often occurs between one hour and one day after ingestion of a lethal dosage. The development of pathologies is frequent, even after single dosages. Definite histologic abnormalities in the myocardium have been reported (Chenoweth, 1950). Hemorrhagic changes in the liver, heart, aorta, and brain are sometimes evident. Gastrointestinal purpura and petechial pulmonary hemorrhages particularly occur in poisoned mammals.

Biochemically, compound 1080 is thought to exert its toxic effect by inhibition or blocking of citrate and succinate metabolism within the Kreb's cycle, (Atzert, 1971). The necessary biochemical transformations and the time required to impair functions account for the lag between ingestion and the development of symptoms.

b. Acute Toxicity

Table III-1 gives a summary of acute oral toxicity figures of compound 1080 for numerous species of mammals, amphibians, and birds. The median lethal single oral dosages expressed as mg compound 1080 per kg. animal weight (LD_{50}'s) range from a very low figure of 0.056 mg/kg for nutria to 60 mg/Kg for the opossum. Even though a 1000-fold range in susceptibility exists between species, all species listed are very sensitive to the toxic action of compound 1080. Relatively few pesticidal chemicals in use are as orally toxic as compound 1080.

Among vertebrates tested, mammals are generally the most sensitive, notably nutria, cotton rat, kit fox, other members of the dog and cat families, and the big brown bat. Over a third of the species listed in the table exhibit LD_{50}'s below one mg/kg. This compound is not readily absorbed through intact skin and inhalation contact for wildlife is not likely (Pattison, 1959).

TABLE III - 1 - ACUTE ORAL TOXICITY OF COMPOUND 1080[1]

SPECIES	LD_{50} mg/kg [2]	REFERENCES [3]
I. MAMMALS		
RODENTS		
Wood rat	1.5	Chenoweth
Calif. ground squirrel	0.35	DWRC Files
Columbia ground squirrel	0.9	Atzert
Fisher's ground squirrel	0.3	Atzert
Tuza pocket gopher	0.25 (60%)	Howard and Marsh
Northern pocket gopher	0.33	DWRC Files
Fresno kangaroo rat[4]	1.0 (100%)	DWRC Files
Polynesian rat	0.60	DWRC Files
Black rat	0.10	Chenoweth
Norway rat	0.22-3.0	Chenoweth
White rat (male)	2.1	DWRC Files
White rat (female)	2.2	DWRC Files
Cotton rat	0.1	Chenoweth
Kangaroo rat	0.1-0.15	Atzert
Rice rat	3.4	DWRC Files
House mouse	8.0	Chenoweth
White mice	12.0	Chenoweth
Meadow mouse	0.5	Chenoweth
Meadow vole	0.92	Atzert
Deer mouse[4]	4.0	Howard and Marsh
Plains prairie dog	0.3 (100%)	Howard and Marsh
Plains prairie dog[4]	0.9 (100%)	Howard and Marsh
Black-tailed prairie dog	0.33	DWRC Files
Nutria	0.056	Atzert
DOMESTIC MAMMALS		
Hereford cows	0.393	Robinson
Hereford calves and steer	0.221	Robinson
Mules (M & F)	0.22-0.44	Tucker and Crabtree
Horse (M & F)	0.35-0.55	Tucker and Crabtree
Swine (M & F)	1.0	Chenoweth
Sheep	0.25-0.50	Atzert
Dog, mixed breeds[5]	0.06	DWRC Files
Cat	0.20	Atzert

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[1] Oral Toxicity by gavage unless otherwise indicated.

[2] If % mortality other than 50%, this appears in parentheses after the mg/kg figure.

[3] DWRC indicates Denver Wildlife Research Center.

[4] Voluntary Feeding

[5] Intravenous

TABLE III - 1 - ACUTE ORAL TOXICITY OF COMPOUND 1080[1]

SPECIES	LD_{50} mg/kg [2]	REFERENCES [3]
OTHER MAMMALS		
Man	0.7-2.1 (est.)	Atzert
Man (children only)	2.0 est.	Howard and Marsh
Rhesus Monkey	4.0	Chenoweth
Mule deer (Male)	0.30-1.00	Tucker and Crabtree
Domestic ferrets (Male)	1.41	Tucker and Crabtree
Big brown bat	0.15	DWRC Files
Commercial mink	0.49	DWRC Files
Desert Kit fox	0.22	DWRC Files
Black-tailed jack rabbit	0.55	DWRC Files
European rabbit	<0.8	Atzert
Opossum	60.0	Atzert
Black Bear	0.5-1.0	Atzert
Bobcat[6]	0.66	Atzert
Coyote	0.1	Atzert
Grey Fox	<0.3	Atzert
II. AMPHIBIANS		
Bull frog (Male)	54.4	Tucker and Crabtree
III. BIRDS		
RAPTORS		
Golden eagle	1.25-5.0	Tucker and Crabtree
American rough-legged hawk[4]	10.0	Howard and Marsh
Marsh hawk[4]	10.0	Howard and Marsh
Great horned owl [4]	10.0	Howard and Marsh
Turkey vulture	20.0 (71%)	Howard and Marsh
Black vulture	15.0	Howard and Marsh

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[1] Oral Toxicity by gavage unless otherwise indicated.
[2] If % mortality other than 50%, this appears in parentheses after the mg/kg figure.
[3] DWRC indicates Denver Wildlife Research Center.
[4] Voluntary Feeding
[5] Intravenous
[6] Intraperitoneal

TABLE III-1 - ACUTE ORAL TOXICITY OF COMPOUND 1080 (Continued)[1]

SPECIES	LD_{50} mg/Kg [2]	REFERENCES [3]
GAME BIRDS		
Gambel's quail (young)[4]	10.0	Chenoweth
Pigeon	4.24	Tucker and Crabtree
Mourning dove	8.55-14.6	Tucker and Crabtree
Ring-necked pheasant (Male	6.46	Tucker and Crabtree
California quail (Female)	4.63	Tucker, et al.
Chukar partridge (M & F)	3.51	Tucker and Crabtree
Coturnix (Male)	17.7	Tucker and Crabtree
Merriam's turkey (Female)	4.0	Tucker and Crabtree
PASSERINES		
Brewer's blackbird[4]	2.0-3.0 (33%)	Howard and Marsh
English sparrow	3.00	Tucker and Crabtree
Magpie	0.6-1.3	Atzert
WILD WATERFOWL		
Mallard (Male)	9.11	Tucker and Crabtree
Mallard (Female)	15.0	Howard and Marsh
Pintail (Male)	10.0	Howard and Marsh
Pintail (Female)	8.0	Howard and Marsh
Widgeon (Male)	3.0	Howard and Marsh
White-fronted goose	5.90	Tucker and Crabtree
DOMESTIC BIRDS		
White leghorn chicken	7.5	Chenoweth
Rhode Island red chicken	5.0	Chenoweth
Pigeon - Florida	10.0 (42%)	Howard and Marsh
Pigeon - Colorado[4]	2.0-3.0	Howard and Marsh

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[1] Oral Toxicity by gavage unless otherwise indicated.

[2] If % mortality other than 50%, this appears in parentheses after the mg/kg figure.

[3] DWRC indicates Denver Wildlife Research Center.

[4] Voluntary Feeding

c. Subacute and Chronic Toxicity

While it was determined that the single LD_{50} of compound 1080 for mallards was 9.1 mg/kg, repeated oral dosages of just 0.5 mg/kg/day for 30 days produced mortality in the same mallard stock. Relative to a number of other pesticides, this indicates a moderate to high degree of cumulative toxic action for this species (Tucker and Crabtree, 1970).

Repeated sublethal doses of compound 1080 have increased the tolerance of some species to subsequent challenging doses. This increase in tolerance is most often slight, however. In other species, such as in the mallard, cumulative intoxication apparently occurs. Accumulation and tolerance for compound 1080 are time-related phenomena such that short-interval treatments (less than 30-hour spacing) are more likely to accumulate. Longer interval treatments (three or more days apart) are more likely not to have cumulative effects. Reports concerning effects of long-term feeding upon low levels of compound 1080 were not found.

Mazzanti, Lopez and Berti (1965) reported that sodium fluoroacetate could cause testicular atrophy in rats. Intubation of 2.5 mg/kg per day for up to 11 days caused progressively greater effects on the seminiferous tubules and testicular weight. These effects were similar to those previously observed after treatment with fluoroacetamide (FAA) and in a subsequent study (Mazzanti, Lopez and del Tacca, 1968) it was demonstrated that recovery from the effects of FAA in rats was nearly complete 165 days post-treatment. No visible effects were observed on the interstitial cells but no tests for endocrine function were conducted.

d. Bioaccumulation and Tissue Residues

As previously stated, the distribution of compound 1080 in animal tissues soon after ingestion is widespread and somewhat evenly concentrated in most soft tissues of the body. Residue chemists often use the whole carcass, or stomach and intestinal tract, as the sample for analyses in suspected compound 1080 poisoning cases. Limited data suggest that tissue residues in compound 1080-killed animals may not generally exceed the LD_{50} amount and in many cases may be somewhat lower than the LD_{50} while gastrointestinal contents may sometimes be much higher.

Rats fed 5.8 mg/kg of compound 1080 were killed after five hours and their tissues analyzed. The heart, brain, kidney, skin plus hair, and whole carcass tissue contained five ppm (Rudd and Genelly, 1956). Presumably, these relationships may vary with the relative dose and latency of symptoms. In summary, compound 1080 probably does not tend to accumulate to any great degree. Death of the animal normally prevents great residue buildup in any tissue or organ system except the gastrointestinal tract.

e. Secondary Toxicity

Several laboratory studies have led the Agency to the conclusion that secondary poisoning of animals (poisoning of animals which eat a victim of direct exposure) can readily occur with compound 1080.

Tucker (1965-72) offered domestic ferrets (Mustela putorius), also known as European polecats, the intact bodies of albino rats which had been stomach-tubed with compound 1080 two hours previously. As the ferrets ate their respective rats over several days, the stated compound 1080 dosages (expressed as mg of compound 1080 per kg of ferret) were not ingested at once nor completely and represented much higher than the actual dosage consumed by the ferrets. Even so, ferrets eating rats containing dosages of 2.0 mg/kg or less exhibited strong symptoms while dosages of 8.0 mg/kg and above were fatal to ferrets.

A similar experiment by Tucker with Peromyscus sp. and ferrets produced death in ferrets if the mice eaten had been stomach-tubed to contain one mg 1080 per kg of ferret weight. The acute oral LD_{50} of compound 1080 stomach-tubed in aqueous solution directly to ferrets was found to be 1.41 mg/kg. If fed in ground beef, the LD_{50} was between one and two mg/kg. Tucker concluded that a ferret which receives two mg/kg whether by direct ingestion or by feeding upon a prey species is very likely to succumb and that levels as low as 0.5 mg/kg can produce severe symptoms lasting up to a week. From this, it is likely that a 650-gram ferret ingesting 1.3 mg (2 mg/kg) of 1080 could die. If, therefore, as little as 1.0 gram of a 2 oz/100 lb. (0.125 percent) bait were ingested directly by a ferret, it would most likely be lethal. If compound 1080-poisoned prairie dogs were fed upon by black-footed ferrets, a similar hazard could exist. The domestic ferrets in these studies ate all parts of the mice completely and variable parts of the rats, including the gastrointestinal tract. Some left only portions of the pelt.

Hegdal, Gatz and Fite (1980) fed Richardson's ground squirrels that had died from eating known amounts of compound 1080 bait to coyotes. Coyotes that died had consumed squirrels that had eaten the equivalent of 0.45, 0.47 and 0.75 mg compound 1080/kg of coyote. Coyotes that survived had eaten the equivalent of 0.14, 0.28 and 0.35 mg/kg. These tests show that a secondary dose of 0.45 mg/kg was lethal and a secondary dose of 0.35 mg/kg was not, implying an LD_{50} of approximately 0.4 mg/kg. Since the LD_{50} for the coyote is about 0.1 mg/kg, secondary risks from compound 1080 are apparently reduced, presumably by processes of absorption, elimination and metabolism when the victim has died from eating bait. These data suggest that a "detoxification factor" of four is appropriate to convert from primary to secondary exposure in the case of Richardson's ground squirrels and coyotes. These results differ from those of Tucker cited above. The extent to which the detoxification factor may vary with other circumstances remains to be determined.

Malloy (1979) fed Colombian ground squirrels that had been killed in the field by 0.05 percent compound 1080 bait to coyotes. No more than one squirrel per day was given to the coyotes and four died after eating 1, 4, 5 and 8 squirrels. A badger similarly exposed survived after eating 19 squirrels. The major weakness of this test is that, in the field, the predators may feed on several dead squirrels in one day and thus obtain substantially larger doses. A cumulative effect of compound 1080 in coyotes is suggested but, since the levels of compound 1080 in the squirrel were unknown, it may be that time of death here is simply related to the probability of consuming a squirrel that had eaten an amount of bait containing multiples of its LD_{50}.

In an experiment by Rudd and Genelly (1956), a dog was killed by eating the heart tissue of a horse five hours after the horse had eaten 4.41 mg/kg of compound 1080. Thus, the available evidence leads the Agency to the conclusion that some secondary poisoning from compound 1080 can be expected, although there is considerable uncertainty in quantifying the risk.

3. Direct Risks to Nontarget Species

Since the purpose of placing compound 1080 treated bait in the field is to kill offending mammals, a risk may be present to individuals of nontarget vertebrate species that may feed on the bait. The major issue is whether such feeding generally results in significant population reductions in the nontarget species. Results of some older field studies of adverse impacts were reviewed in the Rebuttal Analysis (Section II). The following account reviews the results of the most recent investigation (Hegdal et al., 1979).

Under an Environmental Protection Agency (EPA) Interagency Agreement, the U.S. Fish and Wildlife Service, Denver Wildlife Research Center (DWRC) evaluated the hazards to wildlife associated with aerial compound 1080 baiting for California ground squirrels. The study was conducted in Tulare County, in south-central California, in the eastern foothills of the San Joaquin Valley. The study monitored a large-scale operational baiting program conducted by the Tulare County Agricultural Commission.

During early June 1977, about 25,000 ha (60,000 acres) were aerially spot-treated with 0.075 percent compound 1080-treated oat groats at about 6.7 kg/ha (6 lb per swath acre). The actual surface area baited was about 3.4 percent of the treated rangeland.

California ground squirrel populations were reduced about 85 percent following baiting. Primary hazards to seed-eating birds appeared to be negligible as indicated from intensive carcass searching and the results from 31 radio-equipped mourning doves and ten radio-equipped California quail. One of two white-breasted nuthatches found dead after treatment contained compound 1080 residue. One of two samples of dead ants also contained compound 1080 residue. Twelve cottontail rabbits were found dead after treatment and four contained compound 1080 residue, indicating some primary hazard to this species.

These results are consistent with earlier reports; observable direct effects on birds are generally at a level below Agency concern. Effects on rabbits and nontarget rodents are more substantial, but the magnitude of the impact is not readily quantifiable.

4. Indirect Risks to Nontarget Species

A potential for an indirect or secondary risk to vertebrates that feed on rodents intubated with compound 1080 has been demonstrated (Tucker, 1965-1972; Schitoskey, 1975). Translating this potential into realistic probabilities for secondary risks, however, should be done with caution, since our knowledge of the residual toxicity of poisoned animals is limited. The work of Hegdal, Gatz and Fite (1980), discussed earlier, suggests substantial detoxification of the compound 1080 if it is consumed in bait. The Agency believes that well-conducted field studies are useful in assessing risks and relies heavily on the study by Hegdal et al. (1979).

Secondary hazards to raptors and mammalian predators were evaluated by attaching radio transmitters to 24 raptors (red-tailed hawks, turkey vultures, a golden eagle, great horned owls, barn owls, a screech owl, common ravens, a common crow), and 42 mammalian predators (bobcats, coyotes, gray fox, badgers, striped skunks, raccoons, and opossum) and monitoring their movements before, during, and after treatment. Five of the six radio-equipped coyotes and three of the ten radio-equipped bobcats (one bobcat was emaciated, possibly the result of a trap injury), were found dead after treatment. Three dead striped skunks (not radio-equipped) were also found dead after treatment and one contained compound 1080 residue. No other treatment-related mortalities were indicated among the remaining radio-equipped birds or mammals. Also, monitoring of 58 active raptor nests indicated no treatment-related mortalities.

Several aspects of those observations on coyotes and bobcats are relevant:

- While the carcasses showed symptoms typical of compound 1080 poisoning and the general circumstances make it highly likely that death was caused by compound 1080, any residues of compound 1080 were below the level of detection.
- Most of the animals died in locations where their discovery would have been unlikely had they not been equipped with transmitters.
- While the samples are small, the data suggest that from 50 to 100% of local coyote populations and from zero to 50% of local bobcat populations may be killed from the use of compound 1080 to control ground squirrels in similar circumstances.
- A year after the event, coyote numbers appeared to have returned to pretreatment levels.

The results of the study are significant for two reasons. The first is the well-being of the affected nontarget population, taking into consideration its status and related factors. The second is the potential secondary effects of specific predator reduction on the rest of the biotic community.

a. Coyotes

In an earlier review of the Hegdal compound 1080 study on behalf of the USDA, Ketron (1979) concluded that "... a number of coyotes will be killed during rodent control programs using 1080 grain baits. However, for the following reasons, it is very unlikely that long-term populations of coyotes will be significantly affected:

- population models relating the interacting factors indicate that coyote populations can sustain a high annual man-induced mortality, perhaps up to 75 percent,
- areas in which heavy coyote mortality occurs are quickly restocked from adjoining areas, and
- treatment for rodents with 1080 would only be required every three to five years."

The Agency accepts the logic behind Ketron's conclusions, but several qualifications should be made. The population models of Connolly and Longhurst (1975) predict a supression of mean coyote density proportional to the control effort with a potential for extinction not being attained until a repeated annual kill of 75% or greater is achieved. Even though population recovery following cessation of control is possible within a relatively few years, the Agency does not agree that extinction is a reasonable criterion limiting the definition of "significant."

How quickly a depleted area is invaded by peripheral populations is a function of relative scale and population dispersion. Restocking by invasion may be rapid for a local area surrounded by unaffected populations. This is less likely for isolated populations and, if the impact is regional in scale, restocking is unlikely to occur by invasion.

Assuming either an isolated area or a region is treated only every three to five years, reproduction can soon compensate for most losses. If the pattern of control is to rotate the effort among many local populations of ground squirrels over a cycle of three to five years, there will be an annual impact on species that range widely, such as the coyote. The impact depends on the extent to which coyotes are attracted to the areas being controlled. While the Agency has no firm basis for evaluating the regional impact of the use of compound 1080 on coyote populations in California, some impacts beyond merely a temporary supression of local populations may occur.

b. Bobcats

In contrast to the coyote, Ketron (1979) expressed greater concern over bobcat populations because they have been subjected to heavy pressure from fur trappers in recent years. While there is some uncertainty over the potential magnitude of the risk to bobcats associated with ground squirrel control programs, as indicated by the Hegdal study, the Agency cannot agree with Ketron's apparent ambivalence regarding the significance of the impact.

Ketron indicates that "... mortality to bobcats during a program to control ground squirrels would come during the worst possible part of the population cycle — prior to the birth of the kittens." (Baiting before the kittens are independent, as occurs with summer baiting, would be equally bad.) To finally emphasize then that "... the mortality, if any, from rodent control programs would be very small compared to the mortality from fur trapping...," negates the penultimate assessment that "... because of heavy trapping... the mortality of more than a few bobcats during a compound 1080 program might have effects on local populations."

The status of a population is all-important in assessing the impacts of pesticide caused mortality. All sources of mortality and factors affecting successful reproduction must be used to weigh the impact of added stress in a population. The fact that the use of pesticides may not account for the major source of population stress is irrelevant if the resultant additional stress exacerbates the situation.

The Agency concludes that the use of compound 1080 to control ground squirrels poses a secondary risk to local populations of predators such as coyotes and bobcats and that individual coyotes may be somewhat more susceptible to poisoning than individual bobcats. The magnitude of the risk varies with details of the control program and the status of the nontarget population and may extend to regional populations.

c. Community Level Impacts

Predator-prey relationships are complex, not well understood and, hence, predictability is poor and subject to controversy. An abundance of examples exist of how the use of pesticides to control insects has created new pest situations by killing the predators and parasites that formerly kept potential pests in check. The Agency believes that the possible similar relationships between ground squirrels and their predators deserves scrutiny. While there is little basis for believing that predators alone can prevent the development of economic densities of ground squirrels, it is reasonable to suspect that predators can serve a useful function in population management.

There is now substantial evidence that mammalian predator populations, while they seldom may be capable of reducing a high prey population, are capable of suppressing low populations of microtines and lagomorphs and retarding their recovery (Todd, 1981). Support for this position is found in studies of voles in California (Pearson, 1966, 1971), jackrabbits in Utah (Wagner and Stoddart, 1972) and rabbits in Australia (Myers, 1980). To the extent that similar relationships may exist between carnivores and ground squirrels, it follows that the use of a toxicant that kills substantial numbers of carnivores at the very time that the target populations have been reduced to low levels will have the effect of enabling the target population to recover at a more rapid rate. The circumstances under which predation by carnivores and raptors can effectively suppress low populations of ground squirrels needs to be determined, but the Agency suggests that the disruption of natural regulatory mechanisms is an adverse effect beyond the immediate secondary mortality.

5. Risks Associated With the Control of Other Rodents

Except for an incident in which high mortality in geese was associated with the use of both compound 1080 and zinc phosphide to control meadow voles (Hegdal et al., 1979), there appears to be no direct evidence regarding risk to nontarget species from the use of compound 1080 to control prairie dogs, chipmunks, cotton rats kangaroo rats, wood rats, deer mice and meadow mice (voles). By analogy, however, it can reasonably beconcluded that both direct and indirect risk to nontarget organisms can be anticipated. The below-ground use of compound 1080 for controlling pocket gophers would not be likely to lead to substantial exposure to nontarget organism.

6. Relation of Bait Formulations to Risks

Since rates of application, concentrations of compound 1080 in the bait, and methods of application vary substantially, there is reason to investigate the affect of these variables on risks in nontarget organisms as well as efficacy in reducing target species. Unfortunately, there is a paucity of information that would directly permit a very accurate assessment of these relationships. Some reasonable approximations can be made, however, from known facts, estimates and general observations.

Given the LD_{50}, the size of the animal and the concentration of compound 1080 in the bait, the amount of bait required to kill an animal can be estimated. For target species, a practical lethal "dose" would be an LD_{95} for the largest individuals in the population. For nontarget species, risk may be based on an LD_{50} for an average animal or some more stringent criterion for populations of great concern, such as endangered species. Table III-2 indicates some of these toxicity relationships for formulations of compound 1080 currently registered as well as some hypothetical formulations. Broadcasting a two ounce (0.1 percent) bait at six pounds per acre provides 13,000 squirrel doses per acre and about 60,000 meadow vole doses. Hand baiting a one ounce (0.05 percent) bait at 80 burrows per pound provides about 14 squirrel doses per burrow. There is no reason to suspect that the success of a poisoning operation is generally limited by the amount of compound 1080 employed.

A major question from the standpoint of both efficacy and secondary risk concerns the amount of bait normally consumed by the target animals. In an area intentionally over-baited by hand, Sibley (1966) estimated that the average squirrel found dead had consumed about 100 grains of bait. He did not indicate his methods or assumptions and the accuracy of this estimate cannot be assessed. California officials (Rebuttal Number 30000/8: #52) indicate that when baiting is conducted properly, nearly all of the bait is consumed within a few hours after it is placed. Presumably, this observation refers to hand baiting and, since 80 spots per pound yields 5.7 grams per spot and 45 grains/gram yields 250 grains per spot, it is reasonable to conclude that the average squirrel may consume 200 grains of bait if this is applied when there is one squirrel per active burrow.

When bait is broadcast at six pounds per swath acre, it is probably both physically and physiologically impossible for a normal concentration of squirrels to consume most of the bait. Marsh (1967) theorized that "... broadcasting the bait might greatly decrease the secondary hazards of 1080 sometimes associated with hand baiting, because individual rodents would have less chance of finding and consuming hyper-lethal amounts." He concluded, however, that "... considerable more study is needed before any definite conclusion can be made."

Table III-2

Toxicity of Various Compound 1080 Grain Formulations

Compound 1080/100 lb bait	2 oz	1.5 oz	1 oz	0.5 oz	0.25 oz
Nominal Concentration	0.1%	0.08%	0.05%	0.02%	0.01%
Mg Compound 1080 per pound of bait	560	420	280	140	70
Squirrel doses/lb[1]	2200	1700	1100	560	280
Kernels/dose (45 kernels/gram)	9	13	18	36	72
Vole doses/lb[2]	11,000	8500	5500	2800	1400
Kernels/dose	2	3	5	7	15

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[1] A squirrel dose, assuming an LD_{95} of 0.5 mg/kg and a maximum weight of 0.5 kg/squirrel, is 0.25 mg.

[2] A vole dose, assuming an LD_{95} of 1.0 mg/kg and a maximum weight of 50 g/vole, is 0.05 mg.

It seems likely that the amount of bait consumed by squirrels will follow a sigmoid functional response curve related to bait density per se but modified by other factors such as density of ground cover and availability of other foods. There is, however, no information as to where the density/response curve becomes asymptotic. At six pounds per acre (2.4 kernels per square foot), Marsh (1967) estimated that an average of about 83 percent of the bait remained on the ground a day after aerial application. Assuming the pound per acre of missing bait (200,000 grains) was taken mainly by squirrels at a density of 100 squirrels per swath acre, this would provide a dose of about 200 grains per squirrel. Further, since Marsh (1967) observed no differences in efficacy when baiting ranged from 14 to 4 pounds per acre, a reasonable conclusion is that these baiting densities as well as spot baiting are all in the asymptotic zone of the dose/response curve for bait consumption and that 200 kernels (4.5 g) per squirrel is a logical average value to use in assessing secondary risks from current grain baiting practices, regardless of application rates and methods.

Accepting the fact that variable conditions may frequently cause deviations from the modal situation but assuming that 200 kernels per squirrel is an expected dose, secondary risks will depend on the residual toxicity of the bait, the lethal dose for a scavenger and how many squirrels a scavenger is likely to eat. The only estimate of residual toxicity is the value of 25 percent, as observed by Hegdal, Gatz and Fite (1980), cited above. Relying on published LD_{50} values of uncertain accuracy and an approximation of average body weight for nontarget species in California, the number of squirrels killed by compound 1080 required to produce a lethal dose have been calculated (Table III-3).

In drawing conclusions from Table III-3, several qualifications must be noted. First, while the LD_{50} value for the coyote has been reconfirmed in the laboratory (DWRC files), the accuracy of the values for the other species is uncertain. Second, since it seems likely that the greatest exposure comes from the consumption of stomach contents (or cheek pouch contents), animals that selectively either prefer or avoid eating these parts will alter risk accordingly. Finally, the detoxification rate is based on a single study and the Agency has no way to assess the accuracy of extrapolations to other species combinations. More bioassay work is needed before the Agency can determine the reliability of this approach to risk assessment.

If squirrels weigh about 350 g and an 11 kg coyote eats about 10 percent of its body weight, three or four squirrels could readily be eaten where above ground kills are common. One or two squirrels might be a more commonly expected dose, but no data are available for estimating relative frequencies of various doses.

The coyote and kit fox are clearly at great risk from applications of 0.05 percent to 0.1 percent formulations if they feed on dead squirrels. If the LD_{50} value for the bobcat is accurate, it would appear to be at barely marginal risk from the higher formulations. These estimates are reasonably

Table III-3

Number of Squirrels That Consumed 200 Kernels (4.5g) of Compound 1080 Bait Required to Produce a Carnivore LD_{50}, Assuming 75 Percent Detoxification.

	Bait Formulation				
Species, wgt. (LD_{50})	0.1%	0.08%	0.05%	0.02%	0.01%
Coyote, 11 kg (0.1 mg/kg)	0.8	1.2	1.6	3.2	6.4
Bobcat, 7 kg (<0.66 mg/kg)	<3.4	<5.0	<6.8	<13	<27
Kit fox, 2 kg (0.22 mg/kg)	0.3	0.5	0.6	1.3	2.6
Mink, 1 kg (0.5 mg/kg)	0.3	0.5	0.6	1.3	2.6

consistent with the observations of Hegdal et al. (1979) who monitored the effects of an aerial application for the California ground squirrel and the internal consistency (high mortality of coyotes and lower mortality of bobcats) provides some confidence that our risk assessment is reasonable. Using the mink as a surrogate for the black-footed ferret, it appears that there is virtually no margin of safety under similar patterns of baiting.

It seems reasonable to conclude that broadcast application of 0.08 percent and 0.1 percent bait poses equal or greater secondary risks to carnivores than hand application of 0.05 percent bait. It also appears that these secondary risks can be substantially reduced, if not virtually eliminated, by reducing the concentration of compound 1080 in the bait. Primary risks from broadcast applications are necessarily more hazardous than hand application because of the relatively large quantities of unconsumed bait. These risks appear to be limited mostly to granivorous mammals although at least one incident suggests that geese can be put at risk.

7. Risks to Members of Endangered Species

Section 7 of the Endangered Species Act of 1973 (ESA) (16 USC 1531) requires that each Federal agency, in consultation with and with the assistance of the Secretary of the Interior, "insure that any action authorized, funded, or carried out by such agency...does not jeopardize the continued existence of any endangered species or threatened species...." Accordingly, the Departments of the Interior and Commerce have established joint regulations implementing Section 7 of ESA, which include provisions for interagency cooperation and consultation concerning endangered and threatened species and their habitats (50 CFR 402, 43 FR 870-875).

On April 14, 1978, EPA requested formal consultation with the U.S. Department of Interior, Fish and Wildlife Service, under Section 7 of the Endangered Species Act of 1973, on the above-ground uses of compound 1080 as they affect endangered and threatened species. As a result of that consultation, 12 endangered species were identified as animals likely to be exposed to compound 1080 as presently registered by EPA (Appendix D). These are listed as follows:

San Joaquin kit fox (Vulpes macrotis mutica)
Black-footed ferret (Mustela nigripes)
Morro Bay kangaroo rat (Dipodomys heermanni morroensis)
Salt marsh harvest mouse (Reithrodontomys raviventris)
California condor (Gymnogyps californianus)
Aleutian Canada goose (Branta canadensis leucopareia)
Bald eagle (Haliaeetus leucocephalus)
Artic peregrine falcon (Falco peregrinus tundrius)
American peregrine falcon (Falco peregrinus anatum)
Santa Barbara song sparrow (Melospiza melodia graminea)
San Clemente sage sparrow (Amphispiza belli clementeae)
San Clemente loggerhead shrike (Lanius ludovicianus mearnsi)

Of these species, the USDI concluded that risks to the endangered forms of kit fox, ferret, kangaroo rat, harvest mouse and condor were such that new label restrictions which would minimize or preclude exposure were deemed necessary. For the remaining species, the USDI concluded that the continued use of compound 1080 was not likely to jeopardize the continued existence of the species. The Agency concurs in the assessment of the USDI except for the Aleutian Canada goose. As indicated below, the Agency believes that risks to this goose require additional safeguards. The following analysis supplements that by the USDI.

a. San Joaquin Kit Fox

While the Agency is unaware of any reports verifying that kit foxes have been killed by compound 1080 used to control ground squirrels and other rodents, the potential for such an adverse effect appears to be relatively high if kit foxes are exposed to control operations. The compound 1080 LD_{50} for the kit fox approximates 0.22 mg/kg, while that for the coyote is at 0.1 mg/kg. From the viewpoint of risk assessment, this difference is not substantial. Since Hegdal et al. (1979) found that an application of compound 1080 to control ground squirrels resulted in substantial mortality to coyotes, the Agency concludes that the margin of safety for kit foxes is inadequate.

b. Black-Footed Ferret

Assuming a one kg prairie dog consumed as little as four g of a 0.11 percent compound 1080 bait (Colorado registration), 4.4 mg would be ingested. Since only 0.3 mg of absorbed compound 1080 may be sufficient to kill the prairie dog (Table III-2), much of the compound 1080 may not be detoxified and one mg of compound 1080 may remain in the stomach. This amount approximates an LD_{50} for relatives of the ferret, and the Agency concludes that there is no margin of safety for the ferret from the use of compound 1080 to control prairie dogs.

c. California Condor

The assessment of risk from compound 1080 to the condor is complex. Consideration must be given to potential fatality from both single and multiple exposure situations as well as to potential effects on reproduction.

Poisoned ground squirrels are commonly fed on by condors and there is uncertainty as to how much compound 1080 a condor may obtain from such feeding. Koford's (1953) account of the feeding behavior of condors provides no clear indication as to which parts of a squirrel carcass these scavengers will not consume. To assess risk, therefore, it must be assumed that a condor may consume the contents of the cheek pouches and stomach as well as unmetabolized, absorbed compound 1080.

The only available data that deals directly with the amount of compound 1080-poisoned grain contained in cheek pouches and stomachs is contained in the report by Sibley (1966). Sibley reported that 21 out of 51 dead squirrels had compound 1080 grain in their cheek pouches, with an average of 11 grains (0.15 mg compound 1080) per each dead squirrel. The maximum was 234 grains or 3.3 mg compound 1080 in one of the squirrels. The stomach contents included an average of about 100 grains of poisoned oats--approximately eight to nine times the lethal dose. The average squirrel thus contained about 1.5 mg compound 1080 and Sibley concluded that, "If condors are as resistant to 1080 as turkey vultures it would take 200 mg. of 1080 to kill a 22 pound bird. On the basis of the present test it would take 125 squirrels to provide this much poison."

While the above analysis suggests that an ample margin of safety exists for the condor from the use of compound 1080 to control ground squirrels, two basic flaws are present. First, sensitivity of the condor to compound 1080 is assumed to be similar to that of the turkey vulture. The characteristics of the acute toxicity of compound 1080 are such, however, that this assumption cannot be used with confidence. For instance, the reported compound 1080 LD_{50} for the Gambel's quail is 20 mg/kg while that for the California quail is only 2.6 mg/kg — a difference approaching a factor of eight (Clark, 1975.) Similar interspecific variation is present among various mice, rats, lagomorphs, primates, and raptors (Table III-1). Since the sensitivity of the condor is not known and cannot be determined, it is logical to assume that it may be as much as 10 times as sensitive as the turkey vulture. This approximates the LD_{50} of the golden eagle (1.25-5 mg/kg). Thus, the assumptions concerning safety may err by an order of magnitude due to interspecific differences in sensitivity.

Second, the comparative value of 20 mg/kg for the turkey vulture killed 70 percent of the treated animals and, when one is concerned over the potential death of a single condor, such a comparison is inappropriate. Available dose/response information for compound 1080 does not permit extrapolation from an LD_{50} to an LD_1 although the dose/response curve for compound 1080 is considered to be very steep. For purposes of this analysis, it will be assumed that a factor of two is necessary to go from an LD_{50} to a dose of low concern. Employing data from the golden eagle, therefore, a dose of 1.0 mg/kg to the condor would be of concern.

For a 10 kg condor, a dose of 10 mg compound 1080 may pose a potential risk. If the average squirrel contains 1.5 mg compound 1080 and a condor eats three 300 gram squirrels in a day, the margin of safety for the condor is barely adequate. Additionally, since we are concerned about exposure from so few squirrels, the "average" squirrel is of less concern than those individual squirrels that contain substantially more compound 1080 than the average.

Alternatively, one might reason that exposure to bobcats and condors may be similar. If the bobcats killed by aerial application of compound 1080 (Hegdal et al., 1979) consumed a single LD_{50} this would be about 0.66 mg/kg. This differs from the LD_{50} of the turkey vulture by a factor of about 30, again providing a barely adequate margin of safety for individual condors.

Whether or not the condor is susceptible to the cumulative effect of compound 1080 is not known. Roest (1970) reported feeding a turkey vulture poisoned squirrels for 32 days with no observed ill effects. This individual was never observed to eat stomach contents or cheek pouches and the actual dosage of compound 1080 is unknown. However, Tucker and Crabtree (1970) observed that compound 1080 caused mortality to mallards at a daily dose of 0.5 mg/kg for 30 days, whereas the LD_{50} for the mallard is 9.1 mg/kg. Should a condor ingest 0.2 mg/kg compound 1080 per day for 30 days, and respond like the mallard, the risk would be substantial.

The condor's current plight is due primarily to its failure to reproduce (Appendix D). Apparently those few birds that do nest are reasonably successful (Kiff, Peakall and Wilbur, 1979) and it is not known why the remainder do not attempt to breed. Given that background, the observation that exposure to compound 1080 can cause testicular atrophy in rats (Mazzanti et al., 1965) is of major concern.

Rats injected with 2.5 mg/kg compound 1080 on nine occasions over an 11 day period showed a 37% reduction in testicular weight as compared to the controls. The effects were primarily on the germinative epithelium of the semeniferous tubules. While the interstitial cells were not visibly affected, no tests for endocrine function were reported. A subsequent study (Mazzanti et al., 1968) reported that regeneration of the testes of rats treated with flouroacetamide was apparently complete 165 days post treatment.

Since the possible effects of compound 1080 on the testes of birds is unknown, the Agency conducted a preliminary assessment utilizing wild-caught starlings (Sturnus vulgaris) and redwings (Agelaius phoeniceus) (Balcomb et al., 1982). After determining that starlings could survive an exposure of up to 30 ppm compound 1080 in the diet for eight days, birds were exposed to 0 and 15 ppm compound 1080 in the diet for 28 days. Both treatment and control birds varied substantially in their degree of testicular development and differences in testicular weight were not statistically significant. Histological examinations did not reveal significant differences between treated and control birds. Therefore, the Agency has no evidence that compound 1080 affects testicular development in birds. This preliminary test does not, however, eliminate the Agency's concerns regarding possible reproductive effects of compound 1080.

d. Aleutian Canada Goose

The USDI concluded that the use of compound 1080 is not likely to jeopardize the continued existence of this goose. They relied primarily on the facts that the major food source while in California is fescue, velvet grass, plantain and other plants and that there is no evidence to indicate that compound 1080 was causing any mortality. The Agency thinks that the potential for exposure of this goose to compound 1080 warrants greater concern.

Among other uses, compound 1080 may be used to control ground squirrels on the dikes of rice fields and geese may feed in these fields during the fallow period. While the Aleutian Canada Goose may feed primarily on herbaceous matter, the Agency cannot thereby conclude that it will not consume grain when it is available. Twenty percent of a total of 3070 geese killed by poison grain in a rodent control program at Tule Lake National Wildlife Refuge contained compound 1080 treated oats (Hegdal et al., 1979). While the geese in this incident were not Canada geese or its relatives, it seems reasonable to conclude that they would have been at risk had they been present. Canada geese have been killed by strychnine oat baits (Howell and Wishart, 1969). Since exposure to toxic baits could involve a large fraction of the total Aleutian Canada goose population, the materialization of even an unlikely event could have serious consequences.

8. Human/Domestic Risks

The presumption against registration for compound 1080, based on a lack of emergency treatment, was not rebutted because possible antidotes were either unavailable commercially or were of unproven effectiveness against a lethal dose. Before any action can be recommended because of a risk to humans or pets, however, the potential for exposure must also be examined.

Compound 1080 is used primarily for the control of field rodents. Only one product is registered for the control of commensal rodents, and that product is federally registered. Since the issuance of the RPAR, the instructions on the label for that product have been amended to clarify where and how the rodenticide is to be used. It is not to be used inside occupied premises, and the baits must either be placed in areas not accessible to children, pets, and domestic animals or in tamper-proof bait boxes. Also, pets and domestic animals must be confined away from baited areas and all carcasses of pests killed by compound 1080 must be picked up and burned.

These instructions are designed to reduce the exposure to compound 1080, since the greatest risk is to children and pets. During the first four years of compound 1080 use as a rodenticide, 1946-1949, 22 human poisonings were reported. Of those 22 cases, 16 were accidents involving children, two were accidental adult poisonings, and four were reported as suicides. Eleven of the 16 children died and one of the two adults died (Moore, 1950).

Since 1950, ten cases of compound 1080 human poisonings have been reported. One case was an attempted suicide and in two other cases involving adults, compound 1080 involvement is considered highly unlikely. Of the remaining seven cases, three involved adults and four involved children eight years old or younger. The only fatality was one of the adults and this occurred in 1955 (Reigart, et al., 1975; McTaggart, 1970; Rebuttal 30000/8:#52; EPA, PIMS, 1981).

For the period 1966 to 1981, 52 incidents involving domestic animals were reported. Over 110 dogs were killed, more than 10 dogs survived after treatment, 30 other domestic animals (mostly cats) were killed, and three other cats were affected but survived. At least half of the dogs' deaths were the result of possible intentional poisoning (EPA, PIMS, 1981).

The record of accidental poisonings does indicate that use in and around occupied dwellings could constitute an unacceptable hazard. However, the records of accidents since 1950 and the improvement of the instructions for use of the federally registered commensal rodent control product are evidence that exposure of humans and pets to compound 1080 is highly unlikely.

A true antidote to compound 1080 poisoning is not available. If treated immediately, however, and if the amount of poison ingested is not too large, first aid measures (induced vomiting, stomach lavage, purging) are effective.

B. Alternatives

1. Strychnine

A rebuttable presumption against registration was issued by the Agency for strychnine in December, 1976. On November 5, 1981, the Agency published its Preliminary Notice of Determination concluding the Strychnine RPAR and issued an accompanying position document setting forth the basis for the proposed actions. Since the Agency has not yet reached a final decision, the following discussion in no way implies that any currently registered uses will or will not continue to be available. In the discussion of alternatives for each registered use of compound 1080 in Section V, the proposed action will be discussed in terms of proposed Agency actions.

a. Methods of Application for Target Species

1) Ground Squirrels

Strychnine is mixed into baits, usually grains such as oats or barley, but also chopped cabbage or dandelion greens. The final use strength of the baits ranges from 0.2 percent to 0.52 percent strychnine alkaloid. Either one teaspoon or one tablespoon of bait is scattered near the burrow entrance or on runways used by the ground squirrels. This is most often done in the spring during the breeding season but some labels call for repeated treatments if squirrels remain after initial treatment. Many of these labels recommend that bare ground is the best bait placement site. A few others call for placing the bait in the burrow or under brush cover if other wildlife is present. On the average, there are approximately 80 bait placements per pound of bait and a pound may treat 10-15 acres. For heavy infestation, one pound may treat only two to three acres. Oat baits may retain full strength for three days or more on the ground in the absence of rain. A residue loss of approximately 85 percent through degradation occurred in baits 10-18 days after application (Hegdal and Gatz, 1977a).

2) Prairie Dogs

The concentration of the active ingredient of strychnine grain baits for control of prairie dogs vary from 0.3 percent to 0.5 percent. Two teaspoons to one tablespoon of bait is scattered near prairie dog mounds on the side away from the dirt pile. About 0.5 to 3.0 pounds of bait are used per acre in this manner. Some labels caution against use if black-footed ferrets are in the area or direct the user to place the bait under cover of brush or weeds if wildlife hazards exist.

3) Kangaroo and Cotton Rats

Strychnine grain bait is formulated at concentrations of from 0.25 percent to 1.0 percent. Application rates are made by hand in amounts of one or two teaspoonfuls eight to ten feet apart.

4) Pocket Gopher

One tablespoon of 0.35 percent or 0.50 percent bait is placed in the burrow runway with a long-handled spoon. The opening is covered with soil or sod, such that soil does not cover the bait. This use of strychnine was not subject to the RPAR because no substantial risks were perceived. In the case of compound 1080, all uses were considered because of a lack of emergency treatment for human poisonings.

b. Toxicology

1) General

The toxic effect of strychnine is reported to be primarily against the nervous system. The threshold for stimulation of motor effects by external stimuli is lowered, resulting in such signs and symptoms as apparent hyperacusis (painful sensitiveness to sounds), recurrent convulsions or tetanic seizures. Slight touches or light stimuli produce exaggerated responses and often seizures (Tucker and Crabtree, 1970).

The fact that symptoms appear in many species as soon as ten minutes after ingesting strychnine and that recovery of survivors is generally complete within a few hours implies rapid absorption, rapid metabolism in the animal body, and/or elimination of the compound and metabolites (Tucker and Crabtree, 1970).

A compound which is rapidly absorbed in undiluted form and either produces death quickly, or rapid recovery, often displays a "feed-dilution effect." That is, a high concentration of the material, quickly ingested and absorbed, will produce toxic effects. However, if the compound is in such low concentration in feed that absorption is slowed, some of the ingested dosage may be detoxified before all is absorbed. This would effectively reduce the toxic effect (Howard and Marsh, 1973). Strychnine appears to be subject to this effect and hence there are reports of somewhat lower toxicity from baits than would be expected from single oral tests (Ward, et al., 1942). If administered slowly, repeated oral treatments may appear to produce increased tolerance of strychnine. This apparent tolerance may be the result of increasingly rapid elimination and/or metabolism.

Gross pathological examination of numerous wildlife species treated with strychnine at lethal levels revealed occasional hypermia (excess of blood) and hemorrhaging of the gastrointestinal tract, minor endocardial hemorrhages, and massive hemorrhages in the myocardium. Very often no gross pathological change attributable to the action of strychnine occurred.

2) Acute Toxicity

Table III-4 provides a summary of acute oral toxicity values for strychnine relating to various species of mammals, amphibians, and birds.

The acute oral LD_{50} values for the species given in Table III-4 range from 0.75 mg/kg for the coyote and desert kit fox, to 112 mg/kg for the California quail. Most LD_{50} values fall into the range of 1.0 to 25 mg/kg for both mammals and birds.

TABLE III-4 - ACUTE ORAL TOXICITY OF STRYCHNINE ALKALOID

	SPECIES	LD_{50} Mg/Kg[1]	REFERENCES[2]
I.	MAMMALS		
	WILD RODENTS & RELATIVES		
	Calif. ground squirrel	19.9-28.0	DWRC Files DWRC Annual Reports
	Black-tailed prairie dog	1.5	DWRC Files
	Northern pocket gopher	8.3	DWRC Files
	Banner-tailed kangaroo rat	3.7	DWRC Files
	Meadow vole	6.8	DWRC Files
	Calif. meadow vole	22.2	DWRC Files
	Norway rat (wild)	12.0	DWRC Files
	White rat (male)	14.0	DWRC Files
	White rat (female)	5.8	DWRC Files
	Black rat	10.1	DWRC Files
	Polynesian rat	6.8	DWRC Files
	Black-tailed jack rabbit	4.4	DWRC Files
	Nutria	27.0-42.0	DWRC Annual Reports/DWRC Unpublished Data
	CARNIVOROUS MAMMALS		
	Cat	0.75	DWRC Files
	Dog	1.0-1.2	DWRC Files
	Desert kit fox	0.75	DWRC Files
	Coyote	0.7	DWRC Files
	OTHER MAMMALS		
	Man	1.0	Howard and Marsh
	Hog	10.0	DWRC Files
	Horse	2.0	DWRC Files
	Cow	15.0	DWRC Files
	Sheep	7.5	DWRC Files
	Mule deer	17.0-24.0	Tucker and Crabtree
II.	AMPHIBIANS		
	Bull frog	2.21	Tucker and Crabtree

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[1] Data marked (S) if the sulfate was known to be used.
[2] DWRC indicates Denver Wildlife Research Center.

TABLE III - 4 (Continued)

SPECIES	LD_{50} mg/kg[1]	REFERENCES[2]
III. BIRDS		
WATERFOWL		
Mallard	2.9	Tucker and Crabtree
Canada goose	4.0	Tucker and Crabtree
UPLAND GAME BIRDS AND RELATIVES		
Mourning dove	5.12(S)	DWRC Files
Pigeon	21.3	Tucker and Crabtree
Ring-necked pheasant	24.7	Tucker and Crabtree
Ring-necked pheasant	8.48 (S)	Tucker and Crabtree
Chukar	16.0	Tucker and Crabtree
California quail	112	Tucker, et al.
Sage grouse	35-50	Ward, et al.
Turkey	50	DWRC Files
Coturnix	22.6	Tucker and Crabtree
PASSERINES		
Robin	10.0	DWRC Files
House finch	5.6	DWRC Files
English sparrow	4.18	Tucker and Crabtree
English sparrow	4.0-8.0(S)	Tucker and Crabtree
Starling	5.0(S)	Schafer
Red-winged blackbird	6.0	DWRC Annual Reports
RAPTORS		
Golden eagle	5.0	Tucker and Crabtree
Golden eagle	>5.0 (S)	Tucker and Crabtree

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[1] Data marked (S) if the sulfate was known to be used.
[2] DWRC indicates Denver Wildlife Research Center

3) Subacute and Chronic Toxicity

While there are few reports of effects of long-term, low-level exposure to strychnine, it seems likely that rapid metabolism and/or elimination of this material would preclude cumulative toxic action to any marked degree. In addition, the bitter taste of strychnine and rapid onset of symptoms have been demonstrated to produce "bait-shyness" or poor reacceptance of strychnine-containing diets by many species. This phenomenon is known for sage grouse (Farm Chemicals Handbook, 1973), pheasants (Schaffer, 1972), and other species. It is conceivable that "bait-shy" animals might consume such baits after prolonged starvation.

4) Bioaccumulation and Tissue Residues

There is little evidence in the literature to indicate that elevated residues of strychnine can accumulate in animal tissue. Data from a study of 530 albino mice showed no accumulation of strychnine and no tolerance development to increasing dosages of the chemical. Detoxification seemed to be complete within the first 24 hours after administration (Kalning, 1968).

5) Secondary Toxicity

Low persistence of strychnine residues in tissues of animals greatly reduces the chance for secondary toxicity. However, unabsorbed residues in the gastrointestinal tract or cheek pouches of an animal ingesting a large dosage and quickly dying could be sufficient to poison a raptor or carnivore ingesting it. The calculation that fifty squirrels killed by strychnine would have to be eaten by a hawk for a fatal dose (Garlough and Ward, 1932) ignores this major source of risk. There is also a report of secondary poisoning of a kit fox as a result of ingesting strychnine-poisoned kangaroo rats under laboratory conditions (Schitoskey, 1975).

6) Field Data

In a comprehensive study of use of strychnine to control Richardson's ground squirrels, Hegdal and Gatz (1977a) found that most territorial horned larks were killed by the bait. Mourning doves continued to suffer mortality two months after bait application. No mortality to raptors and carnivores was observed but the opportunity to study such effects were less than optimal, mainly because relatively few predators were present in the study area. Raptors, including peregrine and prairie falcons, have been killed from the use of strychnine to control pigeons (EPA, 1980).

7) Summary

Indications are that any likely potential field effects will not be the result of the compound's properties in regard to accumulation, chronic toxicity, reproductive effects, or secondary hazard from the consumption of flesh. Any potential for ecological vulnerability of terrestrial wildlife would appear to be the result of the high degree of acute toxicity by the oral route from either the bait or from bait residue in the gastrointestinal tract or cheek pouches of poisoned animals.

c. Human/Domestic Risks

The lack of emergency treatment criteria was also examined in the PD 1 in deciding if strychnine qualified as an RPAR chemical. After reviewing the available information, the conclusion reached was that an emergency treatment (activated charcoal, barbituates, and muscle relaxants) did exist and a presumption against registration because of that criteria was not warranted.

Although emergency treatment is available and possible, as concluded in PD 1, it must begin within 30 minutes of ingestion. The case histories examined for PD 1 did not include any fatalities. The data reviewed since then indicated a risk to humans, particularly children (EPA, 1976). Most of the hospitalizations and fatalities, however, involved strychnine use that was unrelated to rodent control, (e.g.suicide) or a misuse of the rodenticide. Also, all federally registered strychnine products except hand applied, subsoil uses, are now restricted for use only by, or under the direct supervision of, certified applicators. The Agency believes therefore, that the human risk from the registered uses of strychnine that were the subject of the RPAR are not sufficient to warrant the consideration of new regulatory actions.

2. Zinc Phosphide

a. Methods of Application for Target Species

1) Ground Squirrels

Oat groat or pelleted zinc phosphide baits, which vary in concentration from 1 percent to 2 percent active ingredient, are registered federally (also intrastate in California and Nevada) for use against California and thirteen-lived ground squirrels. Approximately one teaspoon of bait is scattered by hand around each active burrow, or bait is broadcast by machine in 10-15 foot swaths at six pounds per swath acre. Treatment area is usually prebaited at same application rates two to three days prior to application of zinc phosphide.

2) Prairie Dogs

One teaspoon of 2.0 percent steam-rolled oats bait is placed as a single six-inch spot on the edge of each mound or in adjacent feeding area. The treatment area is prebaited one to two days prior to application of zinc phosphide, sometimes aerially. Only one application is made at each site during the period July to December.

3) Meadow Mice (Microtus)

Oat groat or pelleted zinc phosphide baits, which vary in concentration from one to two percent active ingredient, are registered federally (also intrastate in California and Nevada) for use against meadow mice. Bait is scattered around burrows or runways in approximately one-teaspoon amounts.

b. Residues

In soil, zinc phosphide breaks down rapidly to phosphine which is either released into the atmosphere or converted to phosphates, which remain as a residue, and zinc complexes.

There is only a small amount of deterioration of zinc phosphide on baits due to the evolution of phosphine gas; therefore, dry bait must be considered to be toxic indefinitely and must be used accordingly. Lecithin mineral oil, added to zinc phosphide to adhere it to grain bait, offers some protection against moisture, and therefore may increase its stability. Under field conditions zinc phosphide baits may remain toxic for several months until eroded by weathering or decomposition of the carrier or the grain is removed by insects. Physical erosion does not seem to occur rapidly. In one instance zinc phosphide-treated bait, exposed in the field for two to three months and ten to twelve inches of rain, continued to maintain some toxicity.

Residues of zinc phosphide in treated baits collected from the ground were at one third of pretreated amounts by one day after treatment but did not further decline for 21 days. About ten percent of the original residue was found 200 days post treatment. (Hegdal and Gatz, 1977).

c. Toxicology

1) General

Zinc phosphide is a heavy, finely ground gray-black powder that is practically insoluble in water and alcohol. When exposed to moisture, it decomposes slowly and releases phosphine gas (PH_3). Phosphine, which is highly flammable, may be generated rapidly if the material comes in contact with dilute acids. Zinc phosphide concentrate is a stable material when kept dry and hermetically sealed.

When zinc phosphide comes into contact with dilute acids in the stomach, phosphine is released and it is this substance which probably causes death. Animals that ingest lethal amounts of bait usually succumb overnight with terminal symptoms of convulsions, paralysis, and coma. Death usually results from asphyxia. If death does not occur for several days, intoxication occurs similar to that observed with yellow phosphorous in which the liver is heavily damaged. The surface of the liver is spotted and discolored. Prolonged exposure to phosphine can produce chronic phosphorous poisoning. To this extent, zinc phosphide may possess some characteristics of accumulative toxic materials.

Early symptoms of zinc phosphide poisoning are nausea, vomiting (yielding black stomach contents and smell of phosphine), abdominal pain, chest tightness, excitement, and a feeling of coldness. In fatal cases, there is liver, kidney and heart damage. The time between ingestion and death is frequently about 30 hours. Victims who are alive three days after exposure are said to recover completely. Mild poisoning from breathing minute amounts of phosphine gas can be mistaken for food poisoning because of the diarrhea and stomach pains produced.

Zinc phosphide baits have a strong, pungent, phosphorous-like odor (garlic-like), this characteristic seems to attract rodents, particularly rats, but apparently makes the bait unattractive to some other animals.

2) Acute Toxicity

a) Laboratory Data

The acute oral LD_{50} values for zinc phosphide for several avian and mammalian species are given in Table III-5. For rodents, most values are in the 18 to 33 mg/kg range. If the LD_{50} figure for the desert kit fox is typical of carnivores, zinc phosphide is somewhat more toxic to rodents then it is to carnivores. For avian species, all values given are in the range of 7.5 mg/kg to 35.0 mg/kg, with geese being the most sensitive and doves and coturnix the least sensitive. The LD_{50} values for the mammals that could be target animals (prairie dog, ground squirrel, deer mouse) and the nontarget avian species are approximately equal.

b) Field Studies

A field study (Collins, 1966) used 8-14 pounds of two percent zinc phosphide with oat groats aerially applied to 96 miles of ditches and canals for rat control. Researchers found seven dead and 71 live pheasants along the route. Other dead nontarget animals included two mallards, two bitterns, and one rabbit. Whether zinc phosphide was the cause of the deaths was not determined by residue analysis.

The persistence of the toxicity of two percent cracked corn zinc phosphide baits is shown by data of Hayne (1951). When such baits are allowed to weather outdoors, the laboratory mouse LD_{50} from dosing with these baits increased from 2.8 mg/kg on day zero to 4.4 mg/kg in four to six days, to 14.6 mg/kg in 27 days (USDI, May, 1974).

In a nontarget wildlife safety study done under field conditions (Hegdal and Gatz, 1977), some mortality among rabbits and pheasants resulted from orchard mouse control on several square miles of orchards with zinc phosphide. Chemical residue analyses established zinc phosphide poisoning as the cause of the mortality. One blue jay was also killed by zinc phosphide. Otherwise, raptors, predatory mammals, passerines, gallinaceous birds, waterfowl, and avian scavengers suffered no observed mortality. Radiotelemetry tracking of nontarget wildlife provided a useful tool in monitoring the effects.

TABLE III - 5 - ACUTE ORAL TOXICITY OF ZINC PHOSPHIDE[1]

SPECIES	LD_{50} Mg/Kg
I. MAMMALS	
Black-tailed jackrabbit	5.5
White rat	55.1
Norway rat	27.0
Polynesian rat	23.0
Black rat	21.0
Rice field rat	35.0
Banner-tailed kangaroo rat	8.0
California ground squirrel	33.1
Black-tailed prairie dog	18.0
Northern pocket gopher	6.8
Plains pocket gopher	63.0
Meadow vole	18.0
California vole	15.7
Deer mouse	40.5
Nutria	5.6
Muskrat	29.9 (LD_{90})
Desert kit fox	93.0
Dog	40.0[1]
Cat	40.0[1]
II. Birds	
White-fronted goose	7.5
Snow goose	8.8
Mallard duck	37.5
Ring-necked pheasant	16.4
Coturnix quail	35.0
California quail	13.5
European partridge	26.7
Mourning dove	34.3
English sparrow	20-50[2]
Red-winged blackbird	23.7-178.0[2]
Tricolored blackbird	75.0-316.0[2]
Domestic chicken	7.0-17.0[3]

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[1] All values from Denver Wildlife Research Center, USFWS

[2] Approximate lethal dose

[3] Lethal dose

3) Secondary Toxicity

Golden eagles, great horned owls, and coyotes receiving multiple feedings of zinc phosphide-poisoned jackrabbits showed no signs of secondary intoxication (Evans, 1970).

Bell and Dimmick (1975) briefly describe several secondary hazard tests with zinc phosphide involving the feeding of prairie voles to red foxes. Two foxes were fed voles which were dead or dying from zinc phosphide treatment at 5.3 times the LD_{50} for the voles (a total of 86.94 mg/kg). The red foxes consumed 11.5 voles each in 3 days or 10.64 mg/kg zinc phosphide (if the toxicant had been unaltered) and survived though briefly exhibiting altered behavior. The study concluded that "little hazard...may" exist from secondary poisoning.

Zinc phosphide failed to be lethal in a study in which the secondary toxicity of compound 1080 and strychnine was shown for kit foxes ingesting poisoned kangaroo rats. These foxes survived repeated feedings of kangaroo rats each killed by 480 mg of zinc phosphide. This is equivalent to three times the LD_{50} for a kit fox and 29 times the amount one kangaroo rat might consume in field-applied baits (Schitoskey, 1975). The direct dose LD_{50} of zinc phosphide for the kit fox was 93 mg/kg.

Collectively, the literature on secondary poisoning for zinc phosphide shows the low probability of secondary hazard to predatory wildlife which consume target rodents (USDI, April 1976). Some risk to predators may be associated with the consumption of bait stored in the cheek pouches of certain rodents.

d. Human Risks

A dermal toxicity study has shown zinc phosphide to be slightly toxic by dermal exposure, with an LD_{50} of between 2000 and 5000 mg/kg. Although the pesticide is toxic when inhaled, no LD_{50} figures are available. Acute eye and primary skin irritation studies revealed no toxicity (Bell Laboratories, 1980.) Workers are required to wear gloves when preparing or handling baits to prevent skin contact.

3. Anticoagulants

a. Methods of Application for Target Species

CPN (Chlorophacinone) ground squirrel grain baits (usually oat groats or chopped cabbage or dandelion greens) contain 0.005 percent or 0.01 percent CPN. Typically, about one to five pounds of bait are placed in a bait box or hopper bait station intended to exclude wildlife larger than the squirrel. Bait is replenished every few days to give one to four week repeated exposure to the squirrels. Some labels call for broadcasting a handful of bait (usually 0.01 percent A.I.) every other day, three times over a 40-50 square foot area near each burrow or runway.

The methods and rates of DPN (Diphacinone) application are nearly identical to those for CPN described above. Residue persistence data for CPN and DPN were not found.

The other anticoagulants, Pival, Fumarin, warfarin, PMP, and Talon, are applied in a nearly identical manner as CPN, but the concentration of the active ingredient is approximatey five times greater than that for CPN (0.025 to 0.05 percent).

b. Toxicology

1) CPN

Chlorophacinone (CPN) causes death from internal bleeding by hindering coagulation and increasing capillary permeability.

A great degree of species selectivity occurs with CPN. Rodents such as pine voles and deer mice have single oral LD_{50} values of 3.58 mg/kg and 0.49 mg/kg, respectively. On the other hand, the LD_{50} value for red-winged blackbirds is 430 mg/kg and the LD_{50} value for mallards and ring-necked pheasants is greater than 100 mg/kg (Giban, 1969).

In 1969, Giban conducted an experiment to measure the toxic effects of CPN 0.0075 percent baits on the gray partridge during a 15-day exposure. A daily oral dose of 2.25 mg CPN per bird was calculated to be the equivalent of free-feeding on 0.0075 percent baits. All ten partridges survived 15 consecutive daily doses of 2.25 mg. None of ten survived this level for 30 daily doses. Seven of ten survived 15 daily doses of 4.5 mg/bird (Giban, 1969).

2) DPN

Diphacinone (DPN), as with CPN, causes death from internal bleeding by hindering coagulation and increasing capillary permiability. With the amounts of DPN used in baits, rodents must ingest bait on several occasions in order to receive a lethal dose. DPN is also used in human medicine as an anticoagulant.

The acute oral LD_{50} in rats of the technical material is 2.31 mg/kg. An acute dermal LD_{50} was not found in the literature. It was reported that three or four rabbits were killed in a dermal toxicity test in which 200 mg/kg dose was used.

The Velsicol Chemical Corporation (1976) reported the average five-day dietary LC_{50} of DPN (technical) to be 4485 ppm for 14-day-old bobwhite quail. Concentrations of 1000 and 2150 ppm produced 10 and 20 percent mortality. A similar study with 14-day-old mallards found an LC_{50} of greater than 10,000 ppm, although 20 percent mortality and reduced food consumption occurred at this level. (Velsicol Chemical Corporation, 1976).

Truslow Farms, Inc. (1976) reported on an eight week secondary toxicity study with sparrow hawks (Falco sparverius) in which 0.005 percent DPN baits were fed to Swiss mice for three to five days. Six wild hawks (which had been trapped) with a mean weight of 134 grams received two treated mice each day. After 10 days of exposure the hawks were fed untreated mice and held for six weeks observation. There was no effect upon the hawks except lack of weight gain. The mice were terminally poisoned at the time of ingestion by the hawks as shown by studies on identically treated mice not fed to the hawks.

Mendenhall and Pank (1980) demonstrated a potential hazard to avian predators of secondary poisoning from DPN in an experiment using three great horned owls (Bubo virginianus) and one Saw-whet owl (Aegolius acadicus). Two DPN poisoned mice were fed twice daily to the owls for five days. The mice had consumed a lethal dose of 0.01 percent DPN bait over a ten-day period. The saw-whet owl and two of the great horned owls in the test died 7-14 days after the experiment began.

3) Other Anticoagulants

The effects of the other anticoagulants, warfarin, Pival, Fumarin, PMP, and Talon are similar to CPN and DPN in that they all cause death through hemorrhaging. Repeated doses are generally required to cause death. With Talon only one feeding may be necessary although death may not occur for a few days.

c. Human Risks

1) CPN

Human volunteers were given a 20 mg/kg dose and their prothrombin ratings were monitored for eight days thereafter. The rating fell to 35 percent of normal, but it almost completely recovered by the end of the study. It was concluded that ingestion of 400 g of a bait containing 0.005 percent chlorophacinone would depress prothrombin activity to dangerously low levels.

Pesticide Incident Monitoring System (EPA, 1979) files for the year 1966 to June 1979 contain nine reports on CPN poisoning. Five of the reports involved children, one report involved an adult, and the other three involved animals. None of the human incidents were fatal.

2) DPN

The Agency has no data on the human risks associated with the use of DPN as a rodenticide.

3) Other Anticoagulants

The registration standard for Fumarin (EPA, 1980) reported an absence of adequate data to assess acute toxicology and irritation potential, and subchronic oral and inhalation toxicity. The standard requires the use of protective clothing, however, for those who handle technical (manufacturing use) Fumarin.

Between 1966 and October 1980, 1910 incidents of warfarin related poisoning incidents were reported (EPA, 1980). Humans were involved in 1754 of the incidents and the rest of the incidents involved animals, mostly pets. Only one human fatality, (a suicide) and 15 dogs and cat fatalities were reported. Virtually all of the human incidents involved children under five years of age being exposed to household rodenticides.

The Agency has no data on the human risks associated with Pival, PMP, or Talon.

4. Fumigants

a. Methods of Application for Target Species

Gas cartridges, used to control ground squirrels and prairie dogs, are designed to emit toxic gases (primarly carbon monoxide and sulfur oxides) and smoke when ignited. The cartridges are cardboard cylinders filled with such ingredients as sulfur, charcoal, red phosphorous, mineral oil, sodium nitrate, and sawdust. The ignited cartridge is inserted into the burrow and the burrow is then plugged with soil. Gas cartridges are used at times when soil moisture is high enough to prevent seepage of the gases from the burrow into the surrounding soil, generally from fall through spring. Gas cartridges are used to supplement efficacy achieved with toxic baits, or as an alternative toxicant where the used of toxic baits carries a high human risk potential.

Methyl bromide, used to control ground squirrels, is used primarily to control plague outbreaks in ground squirrel populations. The methyl bromide is a colorless liquid that boils at 4-5°C (40.1°F). It is 3.5 times heavier than air, has a burning taste, and an odor resembing that of chloroform. It is usually packaged, under moderate pressure, in metal cylinders. The fumigant is piped into the burrow, or released inside the burrow from an ampule which is broken. The burrow opening is then sealed with soil.

Carbon disulfide, registered for the control of ground squirrels, is piped into the burrow or used to saturate cotton wads which are inserted in the burrows. The burrow opening is subsquently sealed with soil. It is a high volatile liquid which boils at 94.1°C (183.4°F). Carbon disulfide is used primarily in the fall months when ample soil moisture is present. It is not usually the primary fumigant of choice, due to its high degree of flammability and explosiveness.

b. Toxicology and Risks

The effects of gas cartridges on animals are assumed to be the same as those on humans, i.e., unconsciousness followed by a drop in blood pressure, loss of muscular control, and finally a stoppage in breathing.

The effects of methyl bromide are on both the respiratory and central nervous sytems. The central nervous system effects occur with or follow the respiratory system effects by several hours. Respiratory effects include coughing, chest pains, painful breathing, and broncho-pneumonia. Central nervous system effects include nausea, vomit, blurred vision, convulsions, muscle weakness, and respiratory paralysis.

Methyl bromide can cause burns if allowed to saturate clothing, or if splashed in the eye.

Carbon disulfide vapor is absorbed largely through the lungs, although toxic quantities can also be absorbed through the skin. Its effects are mostly on the nervous system; single exposures are characterized by narcosis and its sequelae. Human symptoms of repeated exposure are nervousness, irritability, indigestion, bizarre dreams leading to insomnia, excessive fatigue, loss of appetite, headaches, euphoria, restlessness, mucous membrane irritation, nausea, vomiting, unconsciousness, and terminal convulsions.

PIMS files for the period 1966 to August 1979 contain 21 reports of carbon disulfide exposure through inhalation (EPA, 1979). Eleven incidents involved carbon disulfide alone. The other ten cited carbon disulfide in combination with other ingredients. Five fatalities resulted, all adults, and all from exposure to fumigants where carbon disulfide was one of two or more active ingredients. None of the fatalities involved rodenticidal uses of carbon disulfide.

c. Other Fumigants

Calcium cyanide, a restricted use pesticide, is applied as a dust for control of the Norway rat, roof rat, and house mouse. Death is caused by respiratory arrest, following nausea, unconsciousness, convulsions, and paralysis. The active ingredient combines with moisture in the air and soil to form hydrocyanide acid, a highly toxic gas. Death occurs within minutes after inhalation.

Carbon tetrachloride (under RPAR review), paradichlorobenzene, and ethylene dichloride, all contained in one product, are applied as a liquid. Death results from either respiratory arrest or circulatory collapse.

5. Repellents

The repellent Thiram is sprayed on plants and trees prior to the onset of damage. Little risk to nontarget animals is anticipated since this is not a toxicant when used in this manner.

6. Relative Risks and Comparative Date

Data for making precise comparisons of relative toxicity of compound 1080 and alternatives are not abundant; however, some reasonable generalizations can be derived from Table III-6. The values for the LD_{50}'s are from a variety of sources and have been rounded and averaged. Each of the table values has been derived from one or more species or tests as appropriate.

Some variation between species in reported LD_{50}'s is apparent. The source of this variation is uncertain and most reported differences have not been considered important for the present purposes of seeking generalizations. Substantial variation in toxic response is reported among quail for compound 1080; the LD_{50} for the California quail is about four mg/kg while that for the Gambel's quail is 20 mg/kg. With limited data, therefore, the accuracy of the values is uncertain and the generalizations to be made cannot apply to any similar species that may be either highly sensitive or highly resistant to a particular toxicant.

To obtain the relative risk from the consumption of bait for each species, the LD_{50} values for each toxicant were divided by the concentrations of the toxicant in the bait formulation employed in the USDI field studies. This procedure gives the relative amounts of bait that are equally toxic to the species. Assigning an arbitrary value of 1.0 to the least toxic formulation and dividing the relative amount of bait for the formulation by that for an alternative gives the relative toxicity of the alternative[1/]. Thus, for pheasant, compound 1080 has the lowest LD_{50} but its dilution (0.75 percent) in the bait makes it the least hazardous, other things being equal. Strychnine is less toxic to pheasants than compound 1080 but its higher concentration in bait makes the bait about twice as toxic to pheasants. Considering the quality of the data and other variables, however, the observed difference between the estimates of the two formulations cannot lead to a conclusion that substantial differences in risk can be anticipated for use in the field.

[1/] Example: Dividing each LD_{50} for the pheasant by the concentration of the bait for each pesticide yields the following: strychnine = 25/0.5 = 50; compound 1080 = 7/.075 = 93; zinc phosphide = 18/2 = 9. The relative risk for each toxicant is therefore: strychnine = 93/50 = 1.9; compound 1080 = 93/93 = 1.0; zinc phosphide = 93/9 = 10.

TABLE III-6

Relative Risks of Alternative Toxicants

	Strychnine (0.5% bait)		Compound 1080 (0.075% bait)		Zinc Phosphide (2.0% bait)	
	LD_{50} (mg/Kg)	Relative Risk1/	LD_{50} (mg/kg)	Relative Risk1/	LD_{50} mg/kg)	Relative Risk1/
Quail	135.0	1.0	4.0, 20.0	5.1, 1.0	13.0	42.0
Pheasant	25.0	1.9	7.0	1.0	18.0	10.0
Duck	5.0	6.7	5.0	1.0	36.0	3.7
Goose	4.0	8.4	5.0	1.0	8.0	17.0
Dove	9.0	8.2	11.0	1.0	34.0	8.6
Blackbird	5.0	3.3	2.5	1.0	24.0	2.7
Sparrow	5.0	4.0	3.0	1.0	-	-
Eagle	5.0	1.7-6.6	1.2, 5.0	1.0	-	-
Ground Squirrel	20.0	1.0	0.35	8.6	33.0	2.4
Prairie Dog	1.5	3.0	0.3	2.3	18.0	1.0
Jackrabbit	4.4	8.4	5.6	1.0	8.2	18.0
Cat	0.75	13.0	0.2	7.4	40.0	1.0
Dog	1.1	9.1	0.06	25.0	40.0	1.0
Kit Fox	0.75	31.0	0.22	16.0	93.0	1.0

1/The least toxic bait for each animal is arbitrarily assigned a value of 1.0.

For zinc phosphide, different estimates of the LD_{50} for pheasant (9-27 mg/kg) range from near that for compound 1080 to several times as great.

However, the concentration of zinc phosphide in the bait gives a relative risk factor of from 7 to 21 and averaging 10. From this analysis, it is reasonable to conclude that the risk to pheasants from the use of zinc phosphide is substantially greater than that for both strychnine and compound 1080.

Allowing for the variable quality of these data, and species variability, the information in Table III-6 supports several generalizations about the relative risks of compound 1080 and its alternatives.

a. For a wide variety of birds, compound 1080 bait is the least hazardous. For gallinaceous birds zinc is the most hazardous, but for waterfowl, doves and blackbirds, zinc and strychnine are about equal.

b. Responses among rodents and rabbits appear to be more variable and hence less predictable. Zinc phosphide is the most toxic bait for the jackrabbit and the least for the prairie dog (black-tailed). Compound 1080 is the most toxic bait for the ground squirrel (California) and least for the jackrabbit.

c. For carnivores, the risk from zinc phosphide appears to be relatively low although good toxicity data are difficult to obtain because zinc phosphide may induce vomiting in treated animals. The risk of secondary hazard is further reduced by detoxification of zinc phosphide in the stomach of poisoned animals. In general, the risk to carnivores from strychnine and compound 1080 bait does not differ substantially. The most common exposure of carnivores to grain baits is, however, indirect. The greatest hazard from feeding on strychnine-killed animals is associated with the ingestion of unabsorbed poison in the digestive tract and cheek pouches. This factor may be true for compound 1080 also, but experimentation on this point is inadequate.

d. For raptors (including vultures) comparative data are limited to those on strychnine and compound 1080 for the golden eagle. Because of the problem of indirect exposure to strychnine bait in the digestive system, it is not clear that a substantial difference in secondary risk exists between strychnine and compound 1080. While no raptor toxicity data for zinc phosphide are available, the detoxification of zinc in the stomach of victims would lead to a prediction of relatively low risk to raptors. Some degree of confidence in this prediction is supported by the observations that (1) compared to strychnine and compound 1080, the variability of toxic response is low (reported LD_{50} range over two orders of magnitude in strychnine and compound 1080 and less than an order of magnitude for zinc phosphide) and thus more predictable, and (2) raptors are capable of regurgitating their stomach contents (although not reported for raptors, zinc phosphide may induce regurgitation in carnivores).

Comparative data for anticoagulants are not extensive. Studies using ducks, quail, and blackbirds have suggested very low potential for risk. However, some secondary mortality to raptors has occurred and recent laboratory studies confirm that owls are sensitive to diphacinone poisoning (Mendenhall and Pank, 1980). Additionally, fatalities to dogs have been associated with the use of diphacinone to control orchard mice and it is apparent that these compounds, which have long been emphasized because of their relative safety to humans, may pose significant risks for certain raptors and carnivores.

Fumigants will usually kill any vertebrate inhabiting the treated burrow. The occupants may include black-footed ferrets, burrowing owls, snakes and other species in addition to the target species. No secondary hazards are anticipated from the use of fumigants.

The above observations on apparent relative risk are generally supported by field observation (Hegal and Gatz 1977, 1977a, 1979). It can be concluded that all rodenticides pose risks of varying degree for nontarget birds and mammals, and that the substitution of one toxicant for another may merely shift the risk from one set of nontarget species to another. For instance, substituting zinc phosphide for compound 1080 may substantially reduce risk to carnivores but would increase risks to gallinaceous birds. The actual magnitude of any effects or changes in effect cannot be predicted, but the direction of the change in risks from substitute rodenticides can reasonably be anticipated.

Variation in concentrations of the toxicants, acceptability of the bait and other factors influencing exposure must be considered in the assessments. Table III-6 considers only LD$_{50}$'s and specific bait concentrations. Of substantial concern to the Agency in this regard is the persistence of toxic bait in the field. Fresh baits (leaves, fruits) and pelletized baits may be expected to lose their attractiveness to birds and mammals rather rapidly when exposed to the environment. The observation that strychnine-treated oats were still killing doves after more than two months in the field (Hegdal and Gatz 1977) is disturbing, since little benefit is likely to be derived from such persistence.

7. Summary

Considering use rates, treatment strategies, toxicity data, and field studies, the following discussion characterizes the relative risks inherent in the use of compound 1080 and strychnine and their alternatives for rodent control on croplands, pastures or rangelands.

The risk of strychnine as used in above-ground rodent control appears to center upon population reduction of small birds, such as songbirds and doves, by direct poisoning of birds eating the bait. Other birds and mammals may also be killed but available field evidence does not demonstrate that this effect is generally substantial.

The risk of compound 1080 appears to center upon carnivorous species such as coyotes or bobcats by way of secondary poisoning. Other unrelated families of wildlife, though susceptible according to toxicological studies, did not appear to suffer significant mortality from current compound 1080 ground squirrel control techniques in California.

Zinc phosphide provides some demonstrable hazard to pheasants, geese, and rabbits, but little hazard to other unrelated wildlife species has been established. Secondary poisoning appears to be very unlikely.

The anticoagulants do not appear to have produced any signicant nontarget wildife kills, but do appear to be very selective for rodent-type mammals, and possess ample safety margins for most birds. Some owls and perhaps other untested species are susceptible to secondary poisoning by DPN. Effects of CPN and DPN upon small nontarget wild carnivorous mammals should be investigated further before conclusions of safety are made for such mammals.

Fumigants pose no secondary risk to wildlife but will usually kill nontarget occupants of treated burrows.

IV. BENEFIT ANALYSIS

A. Introduction and Summary

The Agency has evaluated the economic impacts of cancelling compound 1080 for federal and intrastate registered rodenticide uses. This chapter presents the results, in condensed form, of preliminary economic analyses relating to the benefits of compound 1080 use and follows the Administrator's guidelines for economic impact analyses that appeared in the Federal Register, Vol. 41, No. 102 on May 25, 1976. The general approach of this economic analysis is to evaluate the economic impacts assuming compound 1080 is cancelled and users shift to alternative materials or systems. This analysis identifies and/or estimates the quantity of registered compound 1080 bait used[2], lists registered alternatives, and determines changes in treatment costs associated with the use of the next most likely rodent control methods.

The Agency's conclusions regarding economic effects are based on information from a number of sources, principally the Preliminary Benefit Analysis[3]. In addition, rebuttal comments from registrants, users, USDA and other parties, federal and state vertebrate pest control specialists and available published data were considered in the Agency's conclusions.

The Preliminary Benefit Analysis focuses on three general pest situations: agricultural uses (pastures and croplands) to control rodent pests in forage and other crops and nonagricultural uses primarily for the control of commensal rodents. Within these three categories, the Agency has identified major and minor uses to the extent that data permit, estimated quantities of compound 1080 used and listed available alternatives including an evaluation of their efficacy and availability. In addition, the Agency evaluated the impacts from simultaneous cancellation of strychnine, which could substitute for some compound 1080 uses if compound 1080 were cancelled.

The Agency faced considerable data limitations in performing the economic analysis of cancelling compound 1080 uses. In most cases, data necessary for precisely determining economic effects are lacking. For example, almost no field test data were found regarding the comparative efficacy of compound 1080 and alternatives under the complex set of climatic, topographic and edaphic conditions on a site-by-site, species-by-species basis. Likewise, few statistically valid field surveys or data were found on the extent of pest infestation and the damage caused by individual rodent species on individual sites. As a result of these data limitations, the Agency relied on the judgement of knowledgeable Federal, state and local vertebrate pest control specialists in applying the available data in the evaluation of economic consequences of cancelling uses of compound 1080. Thus, this analysis often provides qualitative estimates or discussions of impacts rather than precise quantitative estimates. Although estimates in this chapter are often reported as point estimates, they represent rough predictions of efficacy, bait distribution and economic impacts.

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[2] Not included in this analysis are previously cancelled uses (predacides), uses under Section 18 of FIFRA, or uses of products under old labels which have been subsequently amended by the registrant.

[3] Prepared under contract by Development Planning and Research Associates, Manhattan, Kansas. EPA Contract No. 68-01-4339. 1979.

In general, the Preliminary Benefit Analysis concluded that compound 1080 is the most efficacious and cost effective single-dose rodenticide available for control of field and commensal rodents. While several alternative chemical and nonchemical controls exist and are effective when properly used, they are usually more labor intensive, more costly and generally less effective than compound 1080. The economic impacts of cancelling all uses of compound 1080 will not seriously affect U.S. production or prices of major commodities or services, although local impacts on agricultural productivity or production costs could occur in Colorado, Oregon, and California (the only states with active compound 1080 programs). Economic impacts in the form of higher treatment costs are indicated where available alternatives are notably less effective or much more costly. This could occur especially if strychnine were also unavailable for any currently registered use of compound 1080. Allowing compound 1080 to be registered in more states could reduce control costs in those states currently without a compound 1080 control program.

Treatment costs on agricultural sites (rangelands and croplands) could increase by an average $2.27 per acre, totalling about $1.38 million if compound 1080 is cancelled and strychnine is available (Table IV-1). If both compound 1080 and strychnine[4/] are cancelled, treatment costs on agricultural sites could increase by an average $7.67 per acre, totalling more than $4.6 million annually. Although data limitations precluded in-depth quantitative analysis on nonagricultural sites, no significant consumer impacts at the national level are expected if compound 1080 is cancelled. Isolated community impacts on these sites could result from the inability to rapidly control large infestations of rodents either because alternatives are less effective or require longer time periods to work effectively. For most nonagricultural sites, compound 1080 is used primarily as the chemical of last resort and not as a standard treatment practice.

B. General Production and Use Patterns

Compound 1080 is used in formulated baits consisting of grains, rolled oats or chopped greens for crop and range rodents and in water bait stations serviced by pest control operators for control of commensal rodents. Estimated annual use of 1080 bait (1977-78) was about 610,600 pounds (Table IV-2). About 74 percent of the annual compound 1080 bait usage is for control of ground squirrels, prairie dogs and other rodent pests on rangelands. Approximately 451,000 pounds of bait were used annually on 461,100 acres for control of these pests during 1977-78. Use of compound 1080 for control of ground squirrels and meadow mice on croplands comprises about 21 percent of annual usage or about 129,245 pounds of bait. The remaining 30,500 pounds of compound 1080 bait were used on nonagricultural sites, e.g., grain elevators, warehouses, cemeteries,

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[4/] As presently proposed by the Agency, however, the use of strychnine to control ground squirrels on agricultural sites will not be cancelled.

Table IV-1

Summary: Estimated Economic Impact of Cancelling Compound 1080

Site/Pest	Extent of Use		Increased Treatment Cost			
	lbs of bait	acres treated	with strychnine		without strychnine	
			per acre	total	per acre	total
			dollars			
Agricultural sites	580,130	606,065	2.27	1,376,140	7.67	4,648,845
Rangeland Rodents	450,885	460,970	2.43	1,118,530	7.60	3,405,465
Prairie dogs	36,250	108,750	1.13	123,085	1.13	123,085
Ground Squirrels	411,660	352,220	2.83	995,445	9.32	3,282,380
Miscellaneous	2,975	Unknown	Unknown	Unknown	Unknown	Unknown
Cropland Rodents	129,245	145,095	1.78	257,610	8.57	1,243,380
Prairie dogs	5,415	16,250	1.12	18,200	1.12	18,200
Ground Squirrels	47,368	119,285	1.78	211,780	11.04	1,197,550
Miscellaneous	76,462	9,560	2.89	27,630	2.89	27,630
Nonagricultural Sites	30,500	N/A a/	N/A	Unknown	N/A	Unknown
Rodents	30,500	N/A	N/A	Unknown	N/A	Unknown
Total	610,630	606,065+	2.27	1,376,140+	7.67	4,648,845+

a/ N/A means not applicable.
Source: Development Planning and Research Associates, 1979.

Table IV-2

Estimated Annual Usage of Compound 1080
Bait for Rodent Control, 1977-78

Pest	Range/Pasture		Cropland		Non-Agricultural Sites		Total	
	(lbs)	(%)	(lbs)	(%)	(lbs)	(%)	(lbs)	(%)
Ground Squirrels	411,660	67.4	47,368	7.8	--	--	459,028	75.2
Prairie Dogs	36,250	5.9	5,415	0.9	--	--	41,665	6.8
Other Miscellaneous Rodents	2,975	0.5	76,462	12.5	30,500	5.0	109,937	18.0
Total	450,885	73.8	129,245	21.2	30,500	5.0	610,630	100.0

Source: Development Planning and Research Associates, 1979.

levees, ditch banks, recreation areas. California used 83 percent and Colorado 12 percent of annual bait usage during 1977-78, almost entirely on crops and rangelands. The remaining 5 percent of compound 1080 bait was used on nonagricultural sites for control of commensal rodents throughout the United States.

Compound 1080 is an extremely toxic, relatively quick-acting single dose poison and is not available to the general public. The federally registered product is restricted for use only by, or under the direct supervisor of, Certified Applicators. The same restriction applies to the product recently registered in Oregon.[5/]. In California, the products are applied only under the supervision of officials authorized by the Agricultural Commissioner. In Nevada, an authorized governmental agency or those given a special permit may use compound 1080. Colorado limits use to trained operators. Strict rules are required to be followed by users to assure human safety and to prevent accidental loss or misuse of treated bait. The manufacturer requires a written statement from all purchasers that they follow proper handling and disposal procedures and have valid liability insurance.

C. Analysis of Benefits of Compound 1080 Use on Agricultural Sites

1. Rangelands

Compound 1080 is not federally registered for use on rangelands. However, it is registered for intrastate use in California for ground squirrels, meadow mice, kangaroo rats, and pocket gophers; in Colorado for meadow mice, ground squirrels and prairie dogs; in Nevada for ground squirrels, cotton rats, meadow mice, and pocket gophers; and, under section 24(c) of FIFRA, in Oregon for ground squirrels (Table I-1). Numerous alternatives are registered for ground squirrels and mice in California and three are registered for prairie dogs in Colorado, and four for ground squirrels in Oregon. The chemical alternatives to compound 1080 with their site/pest registrations are listed in Table IV-3. Nevada has an intrastate registration for compound 1080 but has not had an active compound 1080 pest control program during recent years. Thus, if compound 1080 were cancelled, users in California and Colorado would be affected if compound 1080 use were cancelled and Nevada would lose the potential to reactivate its program.

a. Ground Squirrels

In North America, there are 22 recognized species of ground squirrels. Some species contain as many as 14 subspecies which are distinguished not only by

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[5/] Klamath County, Oregon, received a registration for the use of compound 1080 for ground squirrel control under section 24(c) of FIFRA in July, 1981. Because this use was so recently registered, the effects of it's cancellation are not included in this document. The Agency will evaluate the effects of cancelling or modifying this new registration and include a summary of findings in the Position Document 4.

TABLE IV - 3

Chemical Alternatives to Compound 1080

	Ground Squirrels	Chipmunks	Prairie Dogs	Norway Rats: Field Use	Norway Rats: In and around Structures	Roof Rats: Field Use	Roof Rats: In and around Structures	Cotton Rat	Kangaroo Rat	Wood Rat	Deer Mice	Meadow Mice	House Mouse	Pocket Gopher
Acute Toxicants														
Strychnine 1/	F	F	F					F	F		F	F	F	F
Zinc Phosphide	Ca.;Nv.		F	Ca.	F	Ca.	F	F	Ca.	Ca.	F	F	F	Ca.
Antu					F						Ca.			
Red Squill					F		F							
Endrin											F 6/	F 7/		
Gophacide 5/														F
Anti-coagulants														
Diphacinone	Ca.;Co.;Nv.	Ca. 2/		F	F	F	F	Ca. 2/	Ca. 2/	Ca.	Ca.	Ca.; Co. 2/	F	
Chlorophacinone	Ca.;Nv. 2/	Ca. 2/		Ca. 2/	F	Ca. 2/	F	Ca. 2/	Ca. 2/	Ca. 2/	Ca.	Ca. 2/	F	Ca. 2/
Pival	Ca.	Ca. 2/		F	F	F	F	Ca. 2/	Ca. 2/	Ca. 2/	Ca. 2/	Ca. 2/	F	
Fumarin	Ca. 2/	Ca. 2/		Ca.	F	Ca.	F		Ca. 2/	Ca.	Ca. 2/	Ca. 2/	F	Ca.
PMP					F		F						F	
Warfarin	Ca.	Ca. 2/		F	F	F	F		Ca. 2/	Ca. 2/	Ca. 2/	Ca. 2/	F	Ca.
Talon					F		F						F	
Maki 3/					FRP		FRP						FRP	
Fumigants														
Calcium Cyanide				F		F							F	
Chloropicrin				F	F	F	F						F	
Gas Cartridges	F		F	F		F								F
Carbon Disulfide	F	Ca. 2/												F
Methyl Bromide	Ca.;Nv.	Ca. 2/			F		F	Ca. 2/					F	
Carbon Tetrachloride 1/4/	F			F		F								F
Repellents														
Thiram		F										F	F	

F: Federally Registered

FRP: Federal Registration Pending

[1] RPAR Chemical

[2] 24(c) registration in primary county or counties where the rodent is a pest.

[3] For experimental use only.

[4] Formulated with paradichlorobenzene and ethylene dichloride.

[5] Not currently being produced.

[6] Seed protection.

[7] Orchard protection.

morphological characteristics, but also by behavioral differences and varying ecological strategies as well. These latter characteristics frequently affect the efficacy of various control methods.

Currently, six ground squirrel species are considered to be of sufficient economic importance to justify regular control efforts; Richardson's ground squirrel, California ground squirrel, Columbian ground squirrel, Belding's ground squirrel, Townsend's ground squirrel, and Uinta ground squirrel. Other species which occasionally require control include the Antelope ground squirrel, Thirteen-lined ground squirrel, Round-tailed ground squirrel, Golden-mantled ground squirrel, and Rock squirrel. Columbian, Uinta, and Townsend's ground squirrels have increased in numbers during recent years and demands for control efforts for these ground squirrels are increasing.

In range and pasture lands, ground squirrel foraging reportedly reduces the amount of plant material available to grazing livestock. Ground squirrels also eliminate vegetation by clearing and trampling areas near their burrows and runways. In addition to the loss of vegetation, ground squirrels are both a nuisance and a hazard to ranchers. Livestock injury and occasional death losses can result from animals stepping into ground squirrel burrows. Ranchers riding horseback are occasionally thrown and injured as a result of their horses stepping into a ground squirrel mound and/or burrow. Ground squirrel infested range can be difficult to traverse in motorized vehicles as well and damage to equipment has been reported.

Colorado's major ground squirrel pest on rangelands is the Richardson's ground squirrel. An average of approximately 27,350 acres (about 0.1 percent of Colorado's range and pasture acreage) were treated annually with compound 1080 during 1976-78 for ground squirrel control. Control programs are usually conducted in the spring and early summer using an oat bait. Treatment costs with compound 1080 average about $1.01 per acre totaling about $27,625 (Table IV-4). Control with strychnine [6/] could cost about $62,070 ($2.27 per acre) an increase of about $34,445 ($1.26 per acre). Treatment costs with strychnine are higher than with compound 1080 due to higher bait costs and the added costs of prebaiting. Prebaiting is not practiced with compound 1080. If strychnine were also cancelled, the least cost alternative (carbon disulfide at $11.63 per acre) could increase annual control costs by $290,455 annually, an increase of $10.62 per acre (Table IV-4). If diphacinone were used, treatment costs could increase by about $385,545 annually (Appendix E).

6/ In the preliminary decision to conclude the strychnine RPAR, the Agency has published proposed restrictions for strychnine which could affect it's availability as a substitute for compound 1080. However, until the Administrator makes a final determination with respect to strychnine, these restrictions are only proposed actions and could be modified. Thus, consideration must be given to strychnine as an available alternative where appropriate.

Table IV-4

Estimated Economic Impact of Cancelling Compound 1080 for Ground Squirrel Control on Rangeland, 1979[a]

State	Estimated Base Acres Treated	Treatment Cost b/						Increased Treatment Cost			
		Compound 1080		With Strychnine		Without Strychnine		With Strychnine		Without Strychnine	
		Per acre	Total	Per acre	Total	Per acre	Total	Per acre	Total	Per acre	Total
Colorado	27,350	$1.01	$ 27,625	$2.27	$ 62,070	$11.63	$ 318,080	$1.26	$ 34,445	$10.62	$ 290,455
California	324,870	1.33	433,275	4.29	1,394,275	10.54	3,425,200	2.96	961,000	9.21	2,991,925
Total	352,220	1.31	460,900	3.16	1,456,345	10.55	3,715,655	2.83	995,445	9.32	3,282,380

a/ Development Planning and Research Associates, 1979.

b/ Computed as weighted average cost on base acres treated with compound 1080. Includes multiple applications and pre-baiting costs for alternatives.

The control of California ground squirrels, Spermophilus beecheyi, accounts for nearly all the California rangeland treated with compound 1080. About 325,000 acres (Table IV-4) or less than 0.2 percent of California range were treated annually for control of these pests. The principal areas treated are in or near the coastal mountains from central California southward where treatment of one subspecies, S. beecheyi beecheyi; comprises approximately 90 percent of all compound 1080 rangeland applications. An oat groat bait is used to control this large ground squirrel during treatment which occur from spring to fall. An estimated 407,800 pounds of compound 1080 bait were used annually in 1977-1978 — 99.3 percent for ground squirrels and 0.7 percent for mice. About 85 percent of compound 1080 bait is applied by ground methods and 15 percent by aircraft. The weighted average cost of using compound 1080 in California is $1.33 per acre and totaling about $433,000 annually.

If compound 1080 is cancelled for ground squirrel control on rangelands, the most likely alternatives in California include zinc phosphide and strychnine. Fumigants such as gas cartridges and carbon tetrachloride/carbon bisulfide or anticoagulants such as chlorophacinone or diphacinone could also be used; however, usage of these alternatives has historically been confined to relatively limited areas due to labor requirements and/or high costs (relative to single dose poisons such as compound 1080, strychnine and zinc phosphide).

If compound 1080 were cancelled, strychnine would be the least cost control alternative for most of the acres previously treated with compound 1080, but could increase treatment costs for ground squirrel control in California by about $961,000 annually. Higher costs result from higher bait costs and prebaiting. If both compound 1080 and strychnine are cancelled, ground squirrel programs would rely primarily on zinc phosphide, anticoagulants, and fumigants. Treatment costs in California without compound 1080 and strychnine could increase by about $2.99 million or about $9.21 per acre (Table IV-4). For all but the best range sites, treatment costs at this level would be difficult to justify where costs are borne totally by the individual ranchers.

In total, cancelling compound 1080 could increase treatment costs for controlling ground squirrels in rangelands by about $1.0 million ($2.83 per acre) if strychnine is available and by about $3.3 million ($9.32 per acre) if both compound 1080 and strychnine are unavailable.

b. Prairie Dogs

Prairie dog numbers and density decreased greatly between 1930 and 1973. The area occupied by prairie dogs, however, has increased from an estimated 1.3 million acres in 1973 to 2.1 million acres in 1979. Black-tailed prairie dogs are the major pest species, comprising approximately 59 percent of this acreage.

Colorado is the only state where compound 1080 is registered for prairie dog control. Approximately 108,750 acres (less than one percent of Colorado's grazing acreage) are treated annually, at a cost of about $112,000 (Table IV-5). If compound 1080 is cancelled and users substitute zinc phosphide (the least costly alternative) treatment costs could increase by approximately $1.13 per base acre treatment. A combined toxicant-fumigant control program using zinc phosphide and gas cartridges could increase prairie dog control costs by $287,015 or $2.64 per acre.

Table IV-5

Estimated Economic Impact of Cancelling Compound 1080 for Prairie Dog Control on Colorado Rangeland, 1979[a]

Control Material	Base Acres Treated	Treatment Cost		Increased Treatment Cost as Compared to 1080[b]	
		per acre	total	per acre	total
		dollars			
Compound 1080	108,750	1.03	112,015	—	--
Strychnine	108,750	2.15	262,990	1.35	150,975
Zinc phosphide	108,750	1.97	235,100	1.13	123,085
Gas cartridges	108,750	17.02	2,081,905	17.59	1,969,890
Strychnine/		2.15	233,815	—	--
Gas cartridges		17.02	230,985	—	--
combination	108,750	4.27	464,800	3.24	352,785
Zinc phosphide/		1.97	214,240	—	--
Gas cartridges		17.02	184,790	—	—
combination	108,750	3.67	399,030	2.64	287,015

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[a] Development Planning and Research Associates, 1979.

[b] Computed as weighted average cost on base acres treated with compound 1080. Includes multiple applications and pre-baiting costs for alternatives.

c. Miscellaneous Rodents

Compound 1080 is used to a limited extent for control of a variety of miscellaneous rangeland rodents including kangaroo rats, chipmunks, cotton rats, wood rats, deer mice and pocket gophers. An estimated 3,000 pounds of compound 1080 bait were used annually during 1977-78 for control of these rodents. Acute toxins and anticoagulants that are federally registered for control of these pests are shown in Table IV-3.

While sufficient data are not available to quantify the impacts from cancelling use of compound 1080 for control of these rodents, the economic impacts are expected to follow the same general pattern as for ground squirrels and prairie dogs - i.e. higher treatment costs in the range of $1 to $10 per acre. The small amount of compound 1080 used for control of these pests and the availability and effectiveness of alternatives suggest that cancelling compound 1080 use for control of these pests would not have severe economic effects on local, regional or national livestock markets or consumer meat supplies. Impacts will generally be limited to individual ranchers during infrequent periods of high pest populations or local outbreaks.

In summary, impacts on treatment costs from cancelling compound 1080 on rangeland will fall heaviest on control of the Beechey's ground squirrel in California. Costs for controlling ground squirrels and prairie dogs in general could more than double with strychnine available. Ground squirrel control costs could increase about seven times if both compound 1080 and strychnine are cancelled for use on rangelands.

While these increased costs could be severe on individual ranches, the overall area treated is relatively small in relation to total grazing land. As a result, these costs could be largely absorbed by affected individuals. No appreciable effect on regional or national livestock markets or consumer meat prices is anticipated.

2. Croplands

Compound 1080 is not federally registered for use on croplands. However, it is state registered in California, Colorado, Nevada, and Oregon (under section 24(c)) for ground squirrel control and in Colorado for control of prairie dogs. California also has registered compound 1080 for control of meadow and field mice and cotton rats in orchards and other cash crops (Table I-1).

About 129,000 pounds of compound 1080 bait, accounting for 21.2 percent of all compound 1080 bait used, were used annually during 1976-78 to control ground squirrels, prairie dogs and miscellaneous rodents on croplands (Table IV-2). While complete data were not available on the distribution of compound 1080 use by crop, small grains, forages and nuts were the crops most often mentioned as receiving rodent control. Most compound 1080 bait used in croplands protection, about 59 percent or about 76,462 pounds, was used for meadow mouse control, while 37 percent (47,368 lbs.) was used for ground squirrel control and four percent (5,415 lbs.) was used for prairie dog control. Nearly 79 percent of compound 1080 used to control rodents on croplands is in California.

a. Ground squirrels

The species of ground squirrels previously discussed as rangeland pests are the same species responsible for most crop damage by ground squirrels. About 119,285 acres of cropland were treated annually with 47,000 lbs. of compound 1080 bait for control of ground squirrels during 1976-78 (Table IV-6). This comprises less than one percent of the croplands in Colorado and California. Colorado used 22,000 pounds of bait annually during 1976-79, principally to protect alfalfa and small grains on nearly 88,000 acres. California used over 25,000 pounds of 1080 bait, annually on about 32,000 acres. Crops most seriously damaged by ground squirrels in California include nuts, vegetables, barley and alfalfa. Damage has been especially severe on croplands adjacent to infested range or pasture. Intensive control programs are used in these areas on a continuing basis.

Among alternatives to compound 1080, zinc phosphide (registered only in Nevada and California) and strychnine are the most widely used toxicants for ground squirrel control. However, both generally require prebaiting for maximum efficacy, are more costly and reported to be less efficacious than compound 1080 and frequently produce erratic results. The major pest populations of California ground squirrels, the Beechey subspecies, accept strychnine treated bait poorly. Several anticoagulants are registered including pival, fumarin, chlorophacinone and warfarin in California only and diphacinone in California and Colorado. Anticoagulants require multiple baiting for up to 30 days and may cost ten times more than the acute toxicants. Several fumigants including methyl bromide, carbon disulfide and gas cartridges have been used, but usually as a follow-up treatment to single dose toxicants or as spot treatments.

If compound 1080 is cancelled for use to control ground squirrels on croplands, the most likely alternative is strychnine with some use of zinc phosphide. Control costs could increase by about $211,780 annually or $1.78 per acre as compared with current annual treatment costs of $125,590 or $1.05 per acre with compound 1080. If both compound 1080 and strychnine are cancelled, users would most likely rely on fumigants, either methyl bromide or carbon disulfide and to a limited extent on zinc phosphide and anticoagulants, depending on the target pest and crop. Increased treatment costs with these alternatives could approach $1.2 million annually or about $10.04 per acre (Table IV-6).

b. Meadow Mice (Microtus)

Of the states where 1080 is registered, meadow mice are problem pests primarily in California where about 76,500 pounds of compound 1080 baits were used annually during 1976-79 to treat about 9,560 acres. This high treatment rate

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Table IV-6

Estimated Economic Impact of Cancelling Compound 1080 for Ground Squirrel Control on Cropland, 1979 [a]

		Treatment Cost[b]						Increased Treatment Cost			
State	Estimated Base Acres Treated	Compound 1080		With Strychnine		Without Strychnine		With Strychnine		Without Strychnine	
		Per acre	Total	Per acre	Total	Per acre	Total	Per acre	Total	Per acre	Total
Colorado	87,525	$1.01	$ 88,400	$2.27	$ 198,680	$11.63	$1,017,920	$1.26	$110,280	$10.62	$ 929,520
California	31,760	1.17	37,190	4.37	138,690	9.61	305,220	3.20	101,500	8.44	268,030
Total	119,285	1.05	125,590	2.83	337,370	11.09	1,323,140	1.78	211,780	10.04	1,197,550

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[a] Development Planning and Research Associates, 1979.

[b] Computed as weighted average costs on base acres treated with 1080. Includes multiple applications and pre-baiting costs for alternatives.

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is a reflection of the application rate and number of treatments for control of irrupting populations of mice (as high as 3,000 mice per acre). Zinc phosphide is a commonly used toxicant for control of these pests and users would probably use zinc phosphide as the primary alternative on acres previously treated with compound 1080, if compound 1080 is cancelled. Estimated annual treatment costs using compound 1080 are $31,830 or $3.33 per acre. User control costs could increase by about $2.89 per acre totalling $27,630 annually where zinc phosphide is used (Table IV-7). Strychnine could also be used (if available) but at even higher costs.

c. Prairie Dogs

Colorado is the only state where compound 1080 is registered for intrastate use on prairie dogs. Approximately 16,250 acres are treated annually with about 5,415 pounds of compound 1080 bait (less than one percent of total compound 1080 bait usage). The federally registered alternatives are zinc phosphide, strychnine and gas cartridges. Generally, prairie dogs that invade croplands are treated more quickly than are prairie dog infestations on rangelands. Prairie dogs are unable to survive year round on cultivated croplands but may move into adjacent fields when dry conditions reduce their food supply on the inhabited area. Of the total area in Colorado treated for prairie dogs (125,000 acres), croplands represents only 13 percent (16,250 acres).

If compound 1080 is cancelled for use on croplands for prairie dog control, users would most likely shift to either zinc phosphide or strychnine. Zinc phosphide is the least costly of the alternatives. If zinc phosphide is used on acres previously treated with compound 1080, user costs could increase by about $1.12 per acre over the current cost of $1.04 per acre, increasing by about $18,200 annually (Table IV-7). Of the remaining alternatives, strychnine is closely comparable in cost to zinc phosphide treatments. However, gas cartridges are much more labor intensive and more costly at about $17 per treated acre.

d. Miscellaneous Rodents

Other rodents which are occasional pests on croplands include cotton rats, wood rats, Norway rats and pocket gophers. Compound 1080 is registered in California for control of these pests. Usage of compound 1080 for each of these pests on cropland sites is unknown but the amount used is believed to be very low.

Alternatives for control of Norway rats and wood rats in California include zinc phosphide, diphacinone, chlorophacinone, pival, fumarin and warfarin. For control of cotton rats, alternatives include zinc phosphide and strychnine. While sufficient usage data are not available to quantify the impacts from cancelling use of compound 1080 for control of Norway rats, wood rats and cotton rats, the economic impacts on a per acre basis are expected to be within the range of those estimated for ground squirrels and prairie dogs. Thus, user costs could increase in the range of $1-$10 per acre if compound 1080 is cancelled.

Table IV-7

Estimated Economic Impact of Cancelling Compound 1080 for Prairie Dog and Microtus Control on Cropland, 1979a/

State/Pest	Estimated Base Acres Treated	Treatment Cost						Increased Treatment Cost			
		Compound 1080		Strychnine Available b/		Strychnine Unavailable b/		Strychnine Available		Strychnine Unavailable b/	
		Per acre	Total	Per acre	Total	Per acre	Total	Per acre	Total	Per acre	Total
		dollars									
California											
Microtus	9,560	3.33	31,830	6.22	59,460	6.22	59,460	2.89	27,630	2.89	27,630
Colorado											
Prairie Dogs	16,250	1.04	16,900	2.16	35,100	2.16	35,100	1.12	18,200	1.12	18,200

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a/ Development Planning and Research Associates, 1979.

b/ Zinc phosphide is the least cost control method regardless of strychnine's availability.

For pocket gopher control, strychnine is the primary chemical of choice. Compound 1080 is occasionally used for control of pocket gophers on croplands but only after control attempts with strychnine are unsuccessful. Both strychnine and compound 1080 are applied below ground via hand probes or tractor pulled equipment.

If compound 1080 were cancelled for below ground use to control pocket gophers, the overall impact would be very slight since strychnine is the chemical used as the mainstay for pocket gopher control. Below ground uses were not included in the strychnine RPAR; thus strychnine would continue as the standard practice for pocket gopher control. The primary impact from cancelling this use of compound 1080 would be the reduction in the available chemicals for pocket gopher control. No impacts on local, regional or national crop markets are expected.

In summary, the economic effects of cancelling compound 1080 for cropland use will fall heaviest on Colorado where Richardson's ground squirrel and prairie dogs are controlled with compound 1080. Strychnine control of ground squirrels and zinc phosphide control of prairie dogs will about double the costs as compared to compound 1080. If strychnine is also cancelled, costs for ground squirrel control in Colorado could increase substantially and could raise serious questions about the extent of continued treatments on some sites, based on the cost and effectiveness of currently registered alternatives.

If compound 1080 is reregistered as proposed in this RPAR, states currrently without registration could use compound 1080 for field rodent control programs. At the individual producer level, control costs in states without current compound 1080 registrations are somewhat higher than in states with state-sponsored control programs. If states where compound 1080 is not currently available could sponsor control programs in a manner similar to states with existing compound 1080 control programs, individual producers would benefit with reduced control costs. The extent of the cost reduction will depend on several factors.

Where prebaiting is practiced prior to using either strychnine or zinc phosphide, the new compound 1080 program will be somewhat less expensive because compound 1080 control programs generally do not require prebaiting. Thus, the individual producer would save the cost of prebaiting where compound 1080 replaces either strychnine or zinc phosphide. Where prebaiting is not practiced with either strychnine or zinc phosphide, the cost of a compound 1080 program would be very similar to the current cost of using either zinc phosphide or strychnine. Producers would gain a somewhat more effective poison where compound 1080 would replace either strychnine or zinc phosphide. While it is recognized that individual producers in states without a compound 1080 registration could benefit from the use of compound 1080, the extent to which benefits would accrue in these areas could not be quantified with available data.

In addition to simple changes in producer level control costs, states would incur some administrative costs for coordinating and monitoring a compound 1080 control program. To the extent that new resources are required at the state level to coordinate and monitor a new state sponsored program, these costs would somewhat offset the producer level benefit (in terms of lower control cost). The net effect of these distributional impacts could not be quantified with available data.

In California, about 90 percent of ground squirrel control on croplands is directed at the beecheyi subspecies. Strychnine is considered a poor substitute for compound 1080. Without strychnine, fumigation with methyl bromide would probably prove impractical on many presently treated areas. Control of meadow mice in California could probably be achieved using zinc phosphide at just under twice present costs.

Rodent damages on California croplands occur on generally higher valued crops than in Colorado. Fruit and nut crops may be heavily damaged from local outbreaks of ground squirrels, especially during dry summers when native habitat fails to provide adequate food sources. Irrigated small grains and alfalfa may also suffer damages. Quantitative measurements of rodent damage on all the sites where compound 1080 is used are almost nonexistent. Only generalized estimates by informed experts have been reported and are rarely specific to rodent species or crop. In fact, it is quite possible that some of the compound 1080 treatments of rangelands are applied to reduce potential crop damages on nearby land.

Although crop damages due to rodents are poorly documented, many growers believe they can become severe without continued control. This could be especially true near government lands since compound 1080 has been restricted from use on Federal lands. While individual impacts from cancellation of compound 1080 (and strychnine) may be severe, there are no anticipated market or consumer price impacts on major commodities.

D. Analysis of Benefits of Compound 1080 Use on Nonagricultural Sites

Compound 1080 is federally registered for control of commensal rodents (Norway rats, roof rats and house mice) in structures, premises and related sites (e.g., grain elevators, commercial buildings, warehouses, farmsteads, urban dwellings, open dumps, shipholds, etc.). Compound 1080 is registered for intrastate use for the control of ground squirrels, meadow mice, deer mice and other rodents on embankments (e.g., ditch banks, levees, dikes, canals and small earthen dams), nonagricultural turf areas (e.g., golf courses, parks, cemeteries,athletic fields, recreational areas, airport turf runways and military bases) and forest areas (e.g., tree nurseries, tree plantations and reforestation areas). Approximately 5 percent of total compound 1080 usage or 30,500 pounds of bait are used for rodent control on nonagricultural sites.

1. Federally Registered Uses

The only federally registered uses of compound 1080 are for commensal rodent control. Estimates of compound 1080 use for commensal rodent control are not available but the amount used is believed to be very slight.

In practice, compound 1080 use for commensal rodent control is highly regulated, restricted for use by, or under the direct supervision of, certified applicators. For commensal rodent control, several other rodenticides are used as the primary means of control. These include the anticoagulants and zinc phosphide. A continuous program for rat control, for example, alternates the use of various anticoagulants to provide effective control in most situations. Single dose poisons such as zinc phosphide are used to augment the anticoagulants when excessive populations require an eradication program. Compound 1080 is used only if these primary means of control have failed or would not be effective. Thus, while the overall usage of compound 1080 for control of commensal rodents is relatively low, in specific situations no practical alternatives exist. The status of compound 1080 may become increasingly more important if rats resistant to first generation anticoagulants (such as warfarin) were to increase.

If compound 1080 is cancelled for commensal rodent control, the economic impacts, although widespread, could be locally severe. Compound 1080 is only used in those rare cases where extreme economic impacts will result without immediate control of rodent populations. While the overall magnitude of these effects could not be determined, individual examples include business closure and dockage of rodent contaminated grain.

2. State Registered Uses

State registered uses of compound 1080 for rodent control on nonagricultural sites include rodent control on embankments, nonagricultural turf and forest areas. The use of compound 1080 on these sites individually is unknown but the isolated use of compound 1080 implies that few sites are treated.

The Agency was not able to quantify the economic impact from cancelling compound 1080 use on these sites due to limited data. In general, the alternatives, while readily available, are less effective and more costly. Costs of control will increase if compound 1080 is cancelled but more important, because of the lower and/or slower efficacy of alternatives, there may be isolated cases of business closures resulting in loss of income and temporary unemployment. There may also be increased incidences of ditch bank and canal washouts if compound 1080 is cancelled and an effective alternative is not available. Significant social and community impacts could result if sudden infestations of disease-bearing rodents cannot be eliminated with alternatives in the event that compound 1080 is cancelled, although the probability of an uncontrollable infestation is quite low.

The isolated use of compound 1080 for control of rodents in nonagricultural sites implies that only a small number of sites are actually treated. However, when used, compound 1080 is the chemical of last resort. Due to the isolated use of compound 1080 for rodent control on nonagricultural sites, the overall impacts at the national level of cancelling compound 1080 for use on nonagricultural sites are not expected to be significant. However, since compound 1080 use on these sites is a last resort measure, economic effects in individual cases are expected to be severe.

V. RISK/BENEFIT ANALYSIS AND REGULATORY OPTIONS

A. General

The previous two sections have examined the risks and benefits of using compound 1080 for the control of mammals on rangeland and pasture sites, croplands, and nonagricultural sites. The purpose of this section is to compare the risks and benefits for each use, and to evaluate possible regulatory options. Since the risk and benefit data do not always allow for specific site/pest analysis, the evaluation will, for the most part, be presented in general terms.

Certain points are important in the risk/benefit evaluation. These form the key issues in developing the actions which might be taken:

1. Actions to be taken are determined by the existence of risks, not the absence of benefits.
2. The use of a substitute must not increase the risks relative to the benefits.
3. Risk mitigating measures must be economically feasible and viable.

B. Risk/Benefit Analysis

1. Rangeland Rodents

The use of compound 1080 for the control of ground squirrels, prairie dogs, and other rodents on rangelands and pastures presents a risk to nontarget animals, both from primary and secondary poisoning.

The LD_{50} data presented in Section III indicate a primary risk to seed eating mammals and birds. The LD_{50} values for birds are generally greater than those for the target mammals by a factor of about 10. This includes raptors and gallinaceous birds. The general risk to birds appears to be minimal, and this relative lack of risk was demonstrated in the study by Hegdal et al. (1979).

The relative low LD_{50} values for mammals, however, indicate a high potential for risk to most nontarget species. The potential for secondary poisoning is indicated by the LD_{50} values for predators such as the bobcat, coyote, and kit fox. The laboratory study by Schitoskey and the field study by Hegdal et al, (1979) further illustrate the potential for secondary poisoning.

Generally, the risks to nontarget animals other than coyotes and bobcats have not been demonstrated to the extent that a probability of substantial reductions in nontarget populations can generally be anticipated. This conclusion does not preclude the desirability of reducing risks to nontarget animals if the measures adopted do not measurably impact the benefits. For endangered species, however, the loss of one member could be a significant population reduction. As previously discussed in Sections II and III, certain endangered species are at risk from the use of compound 1080. In particular, ground squirrel control in California could jeopardize the San Joaquin kit fox and California Condor, and prairie dog control in Colorado could jeopardize the black footed-ferret.

The Morro Bay kangaroo rat and the salt marsh harvest mouse, both present in California, are not presently at risk from any known compound 1080 uses because of the policies in the state of California, but would be if the rodenticide were to be used within their range.

Both the USDI and the Agency believe that the use of compound 1080, as presently registered, is likely to jeopardize the continued existence of the five species cited above.

The Agency has found no evidence of a risk to nontarget species from the use of compound 1080 to control pocket gophers, nor does the below ground use of this rodenticide pose a known risk to any endangered species.

The risk to nontarget mammals from the other minor rangeland uses, i.e., the control of chipmunks, cotton rats, kangaroo rats, and deer mice, although not substantiated by any field studies, is implied by the LD_{50} values. The risk to nontarget animals from prairie dog control is also not substantiated by direct observations, but the potential for risk to the black-footed ferret is high. The risk to carnivores from ground squirrel control is not only indicated by the LD_{50} values, but the potential for secondary poisoning has been substantiated in the field study by Hegdal et al. The use of compound 1080 for meadow mouse control in alfalfa fields has been partially implicated in a waterfowl kill (Hegdal et al., 1979).

Approximately three-fourths of the compound 1080 bait used is for rangeland protection, with the majority of this (91%) being used to control the ground squirrel. Over 66% of all compound 1080 bait used is for the control of the ground squirrel on rangelands in California, and of this quantity, 85-90% was used to control the Beecheyi subspecies of the California ground squirrel.

The available alternatives for each use of compound 1080 are listed in Table IV-3.

For ground squirrel control, strychnine is federally registered, zinc phosphide is registered in California and Nevada, various anticoagulants (mainly DPN and CPN) are registered in California, Colorado, and Nevada, and two fumigants, gas cartridges and carbon disulfide, are Federally registered.

The increased costs from using alternatives for controlling ground squirrels on rangelands could range from approximately $1.0 million to $3.3 million annually over the current cost of $433,000, depending upon which alternative is used. Strychnine would be the least cost alternative, but it is not considered efficacious for controlling the Beechey's ground squirrel.

Efficacious alternatives are available for prairie dog control, particularly zinc phosphide.[7/] The increased costs from using alternatives could range

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7/ Comments have been received in response to the Strychnine RPAR (EPA, 1980) which indicate that zinc phosphide is not uniformly efficacious. The Agency believes that, if properly applied, zinc phosphide is a viable alternative to Compound 1080 and Strychnine for prairie dog control.

from approximately $123,000 to $287,000 annually over the current cost of $112,000. For the other rangeland rodents, alternative toxicants are available for all except the chipmunk, for which a repellent (Thiram) is Federally registered. No estimates of the cost of using alternatives for controlling rodents other than ground squirrels and prairie dogs (chipmunks, cotton rats, kangaroo rats, deer mice, meadow mice, and pocket gophers) on rangelands are available. The control of these rodents accounts for only 0.5 percent of the compound 1080 bait used annually.

2. Cropland Rodents

The risks of compound 1080 to nontarget birds and mammals are generally the same for controlling cropland rodents as for controlling rangeland rodents. The differences are in the degree of exposure and the endangered species that may be jeopardized.

Twenty-one percent of the compound 1080 bait is used to control cropland rodents, with the majority (60%) being used to control rats and mice. The primary rodent being controlled on croplands is the meadow mouse.

Alternatives are available for all cropland rodents. The approximate annual cost of the use of alternative chemical controls is $28,000 for meadow mouse control (approximately doubling the cost of using Compound 1080) and between $212,000 and $1.2 million for ground squirrel control compared to $125,600 with compound 1080.

In addition to the endangered species listed for rangeland rodents, the Aleutian Canada Goose could be jeopardized from certain cropland uses of Compound 1080. These uses involve baiting applications in or near wetland areas within the migratory range of the Aleutian Canada Goose.

3. Nonagricultural Site Rodent

No specific risk information is available for this use. A reasonable assumption, however, is that a risk to nontarget animals does exist, including all the endangered species mentioned for rangeland and cropland uses. In addition to nontarget wildlife risks, a potential for risks to humans and domestic animals exits from the use of compound 1080 in and around dwellings.

No benefit information is available, other than the use of compound 1080 to control rodents on embankments to prevent failure. Alternative chemical toxicants (in addition to strychnine) are available for all compound 1080 uses on nonagricultural sites with the exception of chipmunks and kangaroo rats.

C. Regulatory Options

1. General

For each of the compound 1080 uses, the Agency can propose any of three options: no action, cancellation, or modification of the terms and conditions of registration. The following discussion elaborates, in general terms, on each of these options. The specifics of each option will then be discussed for each use.

Option 1 - No Action

With this option, the use of the chemical would continue as presently registered. The potential for risks to nontarget animals, including certain endangered species, would continue unabated. The benefits would remain similarly unaltered.

Option 2 - Cancellation

Adoption of this option would eliminate the risks to nontarget animals from the use of compound 1080. A lack of economically feasible or efficacious alternatives could produce a locally significant increase in control costs, or a locally significant increase in damage. Also, the risks of control would not be completely eliminated, since risks to nontarget animals are associated with all the chemical alternatives.

As discussed in Section I, the Agency will be directing intrastate registrants to submit applications and information necessary for Federal registration. Thus, this option would include denial of applications as well as the cancellation of existing registrations.

Option 3 - Modification of the Terms and Conditions of Registration

Based on the risk assessment, available evidence does not now permit the Agency to conclude that substantial risks to nontarget wildlife other than carnivores would generally occur for most uses of compound 1080 if proper precautions are taken and if due concern is given to the protection of endangered species. Some nontarget mortality is to be expected from all uses. Certain use modifications, however, could reduce the risks such that the benefits of use would outweigh the associated risks. These risk reduction measures must not reduce efficacy to the point of eliminating the benefits, since this would result in an implicit cancellation.

General reduction of risks are possible through changes in the characteristics of the bait formulations and the procedures for use. For the protection of endangered species, the major methods of risk reduction are changes in where and when a bait can be used. The following discussion elaborates on these methods.

a. Bait Formulations

A variety of compound 1080 bait formulations are in use for most target species, and a potential for improvement in the balance between efficacy and safety seems apparent. For example, the active ingredient concentration of compound 1080 bait registered for ground squirrel control ranges from 0.05 percent to 0.11 percent for hand baiting and from 0.07 percent to 0.12 percent for aerial application.

Assuming that reduction of a pest population is necessary, if the exact amount of suitable bait could be placed so that at the economic threshold every individual in the target population was likely to be killed with little or no bait remaining, the risks would be minimized and the benefits, in terms of long-term damage reduction, would be maximized. There are practical limitations to achieving such a goal, but improvement is desirable over the present situation, which leaves up to 80 percent of the bait uneaten by the target animal, and which exposes carnivores to multiple lethal doses eaten by the target animal.

b. Application Procedures

The currently registered labels prescribe a variety of instructions designed to reduce the risk to nontarget animals. The degree of risk reduction attainable with each procedure (e.g., "Pickup and burn or bury deeply all carcasses of pests killed by 1080" [Accession Number 8512, Sacramento County]) is not measurable.

Any procedure that may reduce risks, however, without significantly impacting the benefits would be desirable. If an increase in the cost of control would be associated with the procedure, it would be weighed against the potential for risk reduction to determine the viability of the procedure.

Application procedures to be considered include both baiting and post-baiting measures. The placement of the bait, the method of application (hand versus broadcast), and the disposal of uneaten bait and poisoned carcasses are all factors that must be addressed.

The Agency has no present legal or factual basis to prescribe general curatives for risk situations that result from less than optimal management decisions to use compound 1080 in accordance with the label. The development and use of management systems that minimize risks, however, would tend to forestall any future findings of unreasonable adverse effects from the use of compound 1080 and other vertebrate toxicants.

c. Temporal Restrictions

Some populations of endangered species are migratory; hence, individuals of the species may be at risk from the use of compound 1080 only during the time of year when use coincides with their presence. For example, the Aleutian Canada Goose is only in California during the period from October through April. Thus, restrictions on use to protect this migratory bird may only be necessary during those months when excessive exposure is possible.

d. Geographic Restrictions

Many endangered species have highly restricted distributions. Prohibiting the use of compound 1080 within the areas likely to be occupied, with an added buffer zone if necessary, could effectively eliminate the potential for exposure. The scale of the restriction, whether micro- or macrogeographic, would vary with circumstances concerning the predictability of the species' presence and with a need to prevent disclosure of the locations of individuals of the species.

e. Integrated Pest Management

A fourth measure, integrated pest management (IPM), was investigated as a possible risk reduction method. The goal of IPM is to reduce, if not eliminate, the dependency on chemicals and still achieve the degree of pest control believed to be necessary. This could be through habitat manipulation, regulation of grazing intensity, introduction of another species (e.g., a parasite), and/or strategic use of the chemical. The optimal use of a chemical requires exposing the target species to the amount necessary to be fatal, at the time when it is most likely to ingest the bait and when pest densities warrant control. This would reduce the bait exposure to beneficial nontarget species such as predators.

The application of possible IPM methods was discussed with authorities within the Agency, the environmental community, and private enterprises. All believed that this was a desirable area for research and an ideal application of IPM.

Unfortunately, few data were found to form a basis for an IPM option. IPM programs are currently feasible only where there is sufficient knowledge of those parameters involved and when it is possible to exercise control over the parameters. A knowledge of all relevant factors within the ecosystem is necessary to assure not only the intended results but to reduce the probability of any adverse, unintended results. Such information has not been adequately developed for the situations in which compound 1080 is used.

The control of mammals on larger areas using IPM techniques is a matter for further research. Implementation of an IPM program presents further problems. For example, even if a program is of demonstrated feasibility, its use by private applicators cannot be mandated, only stimulated through the elimination or restriction of conventional alternatives. Therefore, the Agency does not believe that IPM is a feasible option for reducing the risks associated with the use of compound 1080 at this time. However it is feasible to incorporate certain IPM principles in managing pest populations without developing a complete program. As indicated in Section III, we do not know the circumstances under which predators can be expected to contribute to the supression of target populations that have been reduced by poisoning operations. However, conducting such operations in ways that are not deleterious to the predators is consistent with IPM principles. Reducing the concentration of compound 1080 in the bait should reduce risks to carnivores and baiting only when economic damage is threatened (California Handbook of Vertebrate Pest Control) contributes to IPM objectives.

2. Rangeland Rodents - ground squirrels

Option 1 - No Action

The risks to nontarget animals, especially certain carnivores, would continue. The field test by Hegdal et al. (1979) demonstrated the possibility of substantial reductions in populations of coyotes and bobcats. The potential risk to the San Joaquin kit fox would depend upon the policy in California regarding use in the range of the kit fox. The benefits of this use, which accounts for approximately two-thirds of all compound 1080 use, would not be affected.

Option 2 - Cancellation

The risks from the use of compound 1080 would be eliminated. If zinc phosphide is used, the risk to gallinaceous birds could increase. The use of anticoagulants also presents a primary and secondary risk to nontarget animals. Fumigants present a risk of primary poisoning to nontarget occupants of the ground squirrel burrows. Zinc phosphide is not considered efficacious for the control of the Beechey's ground squirrel, and the use of anticoagulants or fumigants would substantially increase the cost of control.

Option 3 - Modification of the Terms and Conditions of Registration

o Reduction of active ingredient concentration

Several different concentrations are registered for ground squirrel control. The lowest is 0.042 percent, but the one most commonly used for hand application is 0.05 percent. California, in its Vertebrate Pest Control Handbook, recommends a concentration of not over 0.05 percent with a dosage of one teaspoon per burrow. For aerial application, concentrations range from 0.075 percent to 0.125 percent for grain bait at an application rate of five to six pounds per acre. Cabbage bait registered for aerial application has concentrations of 0.05% at an application rate of 20 pounds per acre and 0.07 percent at an application rate of five to six pounds per acre.

The analysis in Section III indicated that the potential exists to reduce the risks to nontarget animals through a reduction in the percentage of A.I. without reducing the efficacy or impacting the benefits. As shown in Tables III-2 and III-3, a concentration of 0.02 percent should be efficacious in controlling ground squirrels and should provide a better margin of safety to most predators.

A test conducted by the Nevada Department of Agriculture, using a cabbage bait with a 0.00625 percent compound 1080 concentration, produced a ground squirrel activity reduction of 94.5 percent (O'Brien, 1978). Although this test used cabbage bait for controlling Belding ground squirrel, it further demonstrates that considerable latitude exists for reducing the concentration of the active ingredient in all compound 1080 baits without affecting the benefits.

A reduction of the active ingredient concentration should also reduce the risk of primary poisoning to nontarget animals. The Agency has no estimates of the degree of risk reduction that would be attained, but if the efficacy is not affected, the benefit/risk relation can only be improved. The analysis in section III indicates considerable overbaiting for ground squirrel control. Overbaiting implies that a high percentage of the bait is not consumed by the target animals, leaving it available to the nontarget animals and/or that target animals consume multiple lethal doses causing secondary risks. Any modification that reduces the amount of compound 1080 available to both the target and nontarget animals, without reducing the benefits, must be considered.

The risk analysis, Section III, indicated that the ground squirrels tend to eat the same amount of grain bait under current use conditions whether it is broadcast or applied by hand. From this analysis, it is reasonable to conclude that the same active ingredient concentration could be used in both the aerial and hand applied baits. At an application rate of four pounds per acre, enough compound 1080 would be distributed to kill over 2000 ground squirrels per swath acre and the risk to nontarget animals would be substantially reduced. In particular, lowering the aerial application rate would reduce the risk to nontarget mammals of secondary poisoning.

Assuming the A.I. concentration of 0.02 percent and a hand application rate of one teaspoon per burrow or a broadcast application rate of four lbs per acre is efficacious, no impact on benefits is anticipated. In fact, a cost reduction may result since less bait at a lower A.I. concentration will be used.

o Standardization baiting and post-baiting procedures. The risk to nontarget animals, both from primary and secondary poisoning, can be reduced by the adoption of certain baiting and post-baiting procedures. The object of this option would be to standardize the instructions that are on registered labels or in the California Vertebrate Pest Control Handbook and thereby establish a "best practices" list of instructions. The purpose of each provision is to either reduce the amount of compound 1080 available to nontarget animals or to reduce the potential for exposure. Since these procedures are already required in one or more counties or states, the action of making them uniform should not have any appreciable impact on benefits. At a minimum, the procedures that would be on all labels of compound 1080 products registered for the control of ground squirrels on rangeland are:

1. Baiting should not be done unless tests indicate satisfactory bait acceptance will occur in areas to be treated.
2. Keep pets and domestic animals away from treated areas.
3. Clean up all accidentally spilled bait immediately.
4. Do not place bait in piles.
5. Pick up and burn or bury deeply all visible carcasses of animals killed by compound 1080.
6. Do not use within 1/4 mile of a dwelling without first notifying the occupants.
7. All bait shall be dyed yellow in accordance with the California Vertebrate Pest Control Handbook.

The first instruction is in the Guidelines for Baiting Field Rodents in the California Vertebrate Pest Control Handbook. The second instruction is on all registered compound 1080 labels. The third instruction is in the Guidelines and on several California county labels. The fourth instruction is on one California county label.

Instruction five is on two California county labels and on the Colorado label. Instruction six is on one California county label. Instruction seven is in the California Handbook.

Instruction five, the disposal of dead animals, if performed promptly (promptness is desirable both for risk reduction and the minimizing of unpleasantness for the operator) should reduce the potential for secondary poisoning. For instance, a probable factor in the deaths of the predators in the Hegdal study was that the poisoned ground squirrels were not picked up following the baiting operation, leaving the poisoned squirrels available for the carnivores.

Instruction six, prohibiting the use of compound 1080 for the control of field rodents within a prescribed distance of an occupied residence would further reduce the potential for human and domestic risks.

For aerial baiting, the procedures to be used would be those in the California Vertebrate Control Handbook. In addition, the label instruction would include the requirement for dyed bait and the disposal of carcasses.

In conformance with the Federal registration, and the prohibitions on general use for the intrastate registrations, these products would be restricted use pesticides.

o Protection of endangered species

1. California Condor

Critical habitat areas have been determined for the California condor. The estimated population of approximately 30 members inhabits isolated areas in central California. California's policy permits the use of compound 1080 in the range of the condor, and most counties do not take any special precautions when using compound 1080 within its range. The USDI biological opinion expressed a concern for potential mortalities and reproductive effects if the condor is exposed to compound 1080.

With so few members of the species still in existence, an action that merely reduces the likelihood of exposure may not provide a satisfactory margin of safety, particularly in the absence of adequate acute and chronic effects data.

The Agency has proposed the prohibition of the use of strychnine for ground squirrel control in the range of the California condor consistent with current California policy. Should strychnine not be available, the primary available alternatives are zinc phosphide and anticoagulants.

The options to be considered in the protection of the condor are:

a. Take no action, other than the bait formulations and baiting procedure modifications described above.

b. Prohibit use in the range of the condor, possibly making allowances for seasonal habitation, requiring the use of alternatives.

c. Require additional testing to determine the risk of mortality and reproduction effects.

Reducing bait concentration to 0.02 percent and requiring disposal of poisoned ground squirrels should reduce risks to the California condor but the Agency cannot now determine the associated margin of safety, especially with regard to chronic exposure and reproductive effects.

A prohibition of use in the range of the California condor would mean that either zinc phosphide or anticoagulants would be used for ground squirrel control. Zinc phosphide is reported to not be efficacious when used to control the Beechey's ground squirrel and the use of anticoagulants could increase the cost of control by as much as $10 per acre.

Large portions of the eastern and southern range encompass National Forest lands where compound 1080 is not used. Also, the portion of the coastal range population in Santa Clara, Santa Cruz, San Benito, Monterey, and part of San Luis Obispo counties is seasonal, occupying the area from August to December. Baiting for ground squirrel control is usually performed in the late spring.

2. San Joaquin Kit Fox

A critical habitat has not been determined for this species. The current population is located in certain areas in the San Joaquin Valley. When compound 1080 is used in the range of the kit fox, the general policy is to prohibit use within one mile of active dens.

Assuming a high degree of compliance with this policy, the Agency believes that it will substantially reduce risk to the kit fox. Reducing the concentration of compound 1080 in the bait to 0.02 percent should also reduce risks substantially below current practices (Tables III-3) but the Agency does not have the data necessary for an accurate assessment of the margin of safety associated with the reduced concentration.

If the Agency prohibits use of strychnine in the range of the kit fox, as presently proposed, zinc phosphide and anticoagulants would be the primary available alternatives to compound 1080. Prohibitions of the use of compound 1080 in the range of the kit fox would therefore have an impact on the benefits. Treatment costs could increase by almost $10 an acre if alternatives are used.

3. Morro Bay Kangaroo Rat

Approximately 3000 members of this species exist only on a few square miles on the south side of Morro Bay, San Luis Obispo County, California. Roughly one square mile of state parkland and private property has been designated as the critical habitat.

Compound 1080 is not used in the area inhabited by this kangaroo rat as a matter of policy. Should it be used, the potential for fatalities and extinction of the species would be high. Since it is not used, the impacts at prohibition of use would not have an impact on benefits. Also, no restrictions other than prohibition of use in its range would eliminate the potential risk from compound 1080.

4. Salt Marsh Harvest Mouse

No critical habitat has been determined for this species. The range is apparently confined to certain salt marshes and adjoining habitats around San Francisco Bay; areas not inhabited by ground squirrels. The potential for risk is high, however, and the only method to eliminate the risk is prohibition of use. Because compound 1080 is not now being used, in accordance with California policy, prohibition of use would not affect benefits.

3. Rangeland Rodents - prairie dogs

Option 1 - No Action

With this option, the potential for risks to nontarget animals, particularly the black-footed ferret, would continue unabated. The benefits would be similarly unaffected.

Option 2 - Cancellation

The effect of this option would be an elimination of risks from the use of compound 1080 for prairie dog control on rangeland and pasture.

Zinc phosphide, the alternative most likely to be used if compound 1080 is cancelled for this use and if strychnine is not available, is of approximately equal efficacy but could double the cost of control. The risks to gallinaceous birds (and possibly rabbits) are apparently greater from ingesting zinc phosphide baits than strychnine baits. Otherwise, zinc phosphide poses little demonstrated hazard to other wildlife species when properly used. Risks of secondary poisoning are also essentially eliminated. Of particular importance, the toxic risk to the black-footed ferret is virtually eliminated, since secondary poisoning would no longer be likely.

Option 3 - Modification of the Terms and Conditions of Registration

- Reduction of active ingredient concentration (see discussion under "Rangeland Rodents - ground squirrels" on page 82)

The only registration for the use of compound 1080 to control prairie dogs is the Colorado label, with an active ingredient concentration of 0.11 percent and directions to scatter an unspecified amount over a three square foot area around the burrow. With an LD_{50} of 0.33 mg/kg, the LD_{50} dose of compound 1080 for a one kg prairie dog would be 0.33 mg. At 0.11 percent active ingredient, the LD_{50} dose would be available in 0.3 grams of bait. Since one teaspoon of grain bait contains approximately 15 times the LD_{50} dose, one teaspoon of bait scattered over a three square foot area should be a more than sufficient dosage.

The Agency has no direct data to specify an active ingredient concentration of less than 0.11 percent. From the LD_{50} values, however, the Agency has reason to believe that a concentration of less than 0.11 percent would be efficacious, would reduce the risks to nontarget animals and would reduce the cost of baiting. The concentration of the active ingredient would have to be high enough to kill the prairie dog, yet provide a margin of safety to nontarget animals, especially the black-footed ferret. Considering that the LD_{50} of the prairie dog is approximately the same as that of the ground squirrel, an active ingredient concentration of 0.02 percent should prove efficacious. The risk to nontarget animals would be substantially reduced, but an adequate margin of safety may still not be provided for the ferret. The LD_{50} for the ferret is unknown but could be one-sixth that of the prairie dog (0.05 mg/kg), based on the LD_{50} of the mink (0.49 mg/kg), and the possible tenfold interspecific variations in LD_{50}'s (see page 35).

o Standardization of baiting and post-baiting procedures

A prohibition of use for prairie dog control within the range of the black-footed ferret would amount to a cancellation, since the precise range of the black-footed ferret is not known but can be assumed to be wherever the prairie dog exists.

Another option is the alternate recommendation of the U.S. Fish and Wildlife Service. That recommendation was to require a precontrol survey of prairie dog towns and to prohibit the use of compound 1080 if black-footed ferrets were present or thought to be present.

The effectiveness of a search can be questioned and the Agency has no adequate basis for determining the probability of success. The ferret is nocturnal and apparently has acute senses of hearing, sight and smell, making its detection difficult. A prairie dog town would probably have to be monitored for three or four nights to reasonably assure the absence of black-footed ferrets (Ketron, 1979). According to the Ketron report, a well conducted precontrol search, including the use of trained dogs, could allow the use of compound 1080 with a reasonable assurance that ferrets are not present. If this action is proposed, any application for registration or reregistration would have to include a survey protocol to be approved by EPA and the United States Fish and Wildlife Service.

Excluding overhead, training, and administration costs, a precontrol survey could double or triple the cost of using compound 1080 for prairie dog control. This increase could essentially eliminate or reverse the cost differential between compound 1080 and zinc phosphide. If the increased costs are not borne directly by the landowner, the taxpayer would have to be assessed an increased amount.

4. Rangeland Rodents - other rodents (kangaroo rats, cotton rats, deer mice, meadow mice, chipmunks, pocket gophers)

Option 1 - No Action

With this option, the potential for risks of primary and secondary poisoning to nontarget animals would continue unabated. The benefits would be similarly unaffected.

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Option 2 - Cancellation

This option would eliminate the risks from the use of compound 1080 for the control of rodents on rangelands. Very little compound 1080 bait is used for this purpose (less than one percent of the total usage) and it is registered for the control of the chipmunk, cotton rat, and deer mouse only in Nevada, which does not have an active compound 1080 program. Cancellation would therefore not be expected to have a serious impact on the overall benefits, but would eliminate the benefits of this use.

Alternatives are available for the control of all six rodents in this category. Strychnine is registered for the control of all six, but the Agency is proposing cancellation of registrations for chipmunk, meadow mouse and deer mouse control. For kangaroo rat and cotton rat control, the Agency has proposed certain modifications that will allow the benefits of use to outweigh the risks. Zinc phosphide is available for all except the chipmunk, and various anticoagulants are available in California. The use of these alternatives could reduce the risks, particularly of secondary poisoning.

Option 3 - Modification of the Terms and Conditions of Registration

o Reduction of active concentration (see discussion under Rangeland Rodents - ground-squirrels" on page 82).

Based on the analysis of the active ingredient concentration for ground squirrel bait, and the LD_{50} values for the target animals, certain rodents in this category could probably be controlled with lower bait concentrations than those currently registered. The LD_{50}'s for the pocket gopher, kangaroo rat, cotton rat and meadow mouse appear to be approximately the same or lower than the LD_{50} for the ground squirrel. For these four rodents, then, the active ingredient concentration could be the same as for ground squirrel bait, or 0.02 percent. The dosage for all four rodent baits would be one teaspoon. For aerial baiting for meadow mice control, the dosage would be four to five pounds per acre. The LD_{50} value for the chipmunk is not known, and the LD_{50} of the deer mouse is an order of magnitude greater than the LD_{50} for the ground squirrel. For these two rodents, then, the active ingredient concentration could be the lowest one currently registered, or 0.05 percent. The dosage would be one teaspoon.

o Standardization of baiting and post-baiting procedures.

The discussion under "Rangeland rodents - ground squirrels" for this method is applicable here also. The procedures for aerial baiting are applicable for meadow mouse control.

o Prohibition of use in the range of endangered species.

No endangered species are known to be at risk from the use of compound 1080 to control rodents other than ground squirrels and prairie dogs on rangelands.

5. Cropland Rodents - ground squirrels

The available options, and their impacts, are the same as for ground squirrels on rangeland with the exception of the protection of endangered species provision under the modification option.

The California condor and the San Joaquin kit fox are of concern for this use also, although the likelihood of exposure is reduced since these two endangered species are not often found in croplands. With endangered species, however, precautions must be taken whenever the potential exists for fatal or reproductive effects. Thus, the same protective measure options for the condor and kit fox under "Rangeland Rodents - ground squirrels" are applicable here also. Additionally, the protective measure options for the Morro Bay kangaroo rat and the salt marsh harvest mouse are applicable.

The Aleutian Canada Goose is also potentially at risk from the use of compound 1080 to control ground squirrels on croplands. A critical habitat has not yet been established for this species. Its migration route in the fall includes the northwestern California coast and interior California river valleys. In early spring, the Aleutian Canada Goose migrates back to the Aleutian Islands.

Generally, compound 1080 is not used in wetlands during the time that the goose is in California. Fumigants, zinc phosphide, and anticoagulants (mainly DPN) are used for levee maintenance, the latter two alternatives being used in bait stations.

The options to be considered for the protection of the Aleutian Canada Goose are:

1) Prohibition in the entire California range of the goose
2) Prohibition in the areas closed to goose hunting
3) No action other than proposed bait formulation and baiting procedures modifications discussed earlier
4) Requiring the use of bait stations
5) Temporal restrictions

If the use of compound 1080 is prohibited, an alternative chemical would have to be used. The cost of control could increase by as much as approximately ten dollars an acre. The total increase in cost is not known since the time of baiting for ground squirrels does not generally coincide with the time the goose is in California. The use of zinc phosphide would present a greater risk to the Aleutian Canada Goose than would compound 1080. The use of anticoagulants would substantially reduce the risks relative to compound 1080.

Reducing the bait concentration and standardizing baiting procedures would not preclude the possibility of exposure to a lethal quantity of compound 1080 bait. Combining these two provisions with the use of bait stations should virtually eliminate the risk to the goose without impacting benefits.

Any prohibition of use need only be applied during the period when the goose is in California, with an allowance for time needed for uneaten bait to be degraded. From the figures in Hegdal and Gatz (1979), the bait may be reduced from an active ingredient concentration of 0.075 percent to approximately 0.005 percent after 30 days on the ground.

6. Cropland Rodents - prairie dogs

The available options, and their impacts, are the same as for prairie dogs on rangelands (see page 86).

7. Cropland Rodents - other rodents (meadow mice, Norway rats, cotton rats, wood rats, pocket gophers)

Option 1 - No Action

With this option, the potential for risks to nontarget animals, including the Aleutian Canada goose, would continue unabated. The benefits would be similarly unaffected.

Option 2 - Cancellation

Cancellation of compound 1080 uses for this category would eliminate the associated risks to nontarget species. Alternatives, mainly zinc phosphide and anticoagulants, are available for the control of all five target rodents listed above. Strychnine is registered for meadow mouse control, but the Agency has proposed to cancel this use. The use of the other alternatives could reduce risks, but the use of zinc phosphide in the range of the Aleutian Canada Goose would increase the risks to that endangered species.

Cancellation would mostly impact on the benefits derived from meadow mouse control. Although efficacious alternatives are available, compound 1080 is preferred for controlling severe outbreaks. Also, the use of alternatives would increase costs slightly.

Option 3 - Modification of the Terms and Conditions of Registration

The discussions regarding bait formulations and baiting procedures under "Rangeland Rodents - Ground Squirrels" (see page 81) and "Rangeland Rodents - other rodents" (see page 87) are applicable here also. The active ingredient concentration of Norway rat, meadow mouse, cotton rat and pocket gopher bait would be 0.02 percent at a dosage of one teaspoon (or four to five pounds per acre for aerially applied meadow mouse bait). Wood rat bait would have an active ingredient concentration of not over 0.05 percent and a dosage of one tablespoon.

The discussion and options under "Cropland Rodents - ground squirrels" (see page 89) with respect to the protection of the Aleutian Canada Goose are applicable here for Norway rat and meadow mouse control.

8. Rodents on Nonagricultural Sites

This category comprises both the commensal rodents under the Federal registration (Norway rats, roof rats, and house mice) and field rodents under state registrations (ground squirrels, chipmunks, cotton rats, kangaroo rats, wood rats, deer mice, meadow mice, and pocket gophers). The discussion of the available options for rodents on nonagricultural sites will consider the commensal rodents and the field rodents separately when appropriate.

Option 1 - No Action

Under this action, the potential for risks to nontarget animals, including the Aleutian Canada Goose, would continue unabated. The benefits would be similarly unaffected.

Option 2 - Cancellation

With this option, the risks to nontarget animals from the use of compound 1080 would be eliminated. No figures are available for the costs of using alternative means of control. The major effect on benefits would be the loss of what is considered by many certified applicators to be the method of last resort for control. Substitute chemical and nonchemical controls are available for all uses in this category, and many, primarily anticoagulants and zinc phosphide, are already being used in some California counties.

Option 3 - Modification of the Terms and Conditions of Registration

Since only the Federal registration for the technical grade product is for the control of commensal rodents, standardization of baiting formulation and baiting procedures does not apply. The Federal label contains precautionary statements to reduce the risks to humans, pets, and nontarget wildlife.

For the field rodents, the discussions under "Rangeland Rodents - ground squirrels" and "Rangeland Rodents - other rodents" are applicable here also. Ground squirrel, cotton rat, kangaroo rat, meadow mouse and pocket gopher baits would have an active ingredient concentration of not over 0.02 percent at a dosage of one teaspoon. Chipmunk, wood rat and deer mouse bait would have an active ingredient concentration of not over 0.05 percent at a dosage of one teaspoon.

The baiting and post-baiting procedures discussed under "Rangeland Rodents - ground squirrels" are applicable for the control of field rodents on nonagricultural sites also.

The discussion and options under "Cropland Rodents - ground squirrels" with respect to the protection of the Aleutian Canada Goose are applicable here for noncommensal Norway rat and meadow mouse control.

D. PROPOSED ACTIONS

The following proposed actions are a result of the Agency's analysis of the risks and benefits of the use of compound 1080 and the Agency's assessment of what it believes to be feasible regulatory options.

The proposals are based on the best information available to the Agency and its interpretation of the data. These proposals are not the Agency's final determination. The purpose of publishing proposed actions and providing a comment period for public response is to elicit information that may have been missed, to correct misinterpretations of existing information, and incorporate other expert opinion into its decisionmaking process. The Agency is fully prepared to alter any of the proposed actions in response to convincing arguments that the proposed actions is for some reason infeasible, or does not achieve the best balance of risks and benefits.

1. Rangeland Rodents - ground squirrels

The Agency proposes adoption of the modification of the terms and conditions of registration option. This decision is based on a lack of economically feasible efficacious alternatives and the potential for reducing the risks to nontarget animals through the standardization of bait formulations and baiting and post-baiting procedures. With these modifications, the Agency believes that the benefits of the use of compound 1080 to control ground squirrels on rangeland will outweigh the associated risks.

For this use then, the Agency proposes the following modifications:

a. Standardize bait concentrations at a maximum of 0.02 percent active ingredient and a dosage of one level teaspoon/burrow for hand application, a maximum of 0.02 percent active ingredient and a dosage of four pounds per acre for broadcast application of grain bait, and a maximum of 0.02 percent active ingredient and a dosage of five to ten pounds per acre for broadcast application of green bait.

b. Standardize hand baiting and post-baiting procedures to read:

   - Baiting should not be done unless tests indicate satisfactory bait acceptance will occur in areas to be treated.
   - Keep pets and domestic animals away from treated areas
   - Clean up all accidentally spilled bait immediately
   - Do not place bait in piles
   - Pick up and burn or bury deeply all visible carcasses of animals killed by compound 1080
   - Do not use within 1/4 mile of a dwelling without first notifying the occupants.
   - All bait must be dyed yellow in accordance with the California Vertebrate Pest Control Handbook

c. Standardize aerial baiting and post-baiting procedures to read:

   - use in accordance with the Guidelines for Applying Rodent Baits by Aircraft for Control of Ground Squirrels in the California Vertebrate Pest Control Handbook
   - Pick up and burn or bury deeply all visible carcasses of animals killed by compound 1080
   - All bait must be dyed yellow in accordance with the California Vertebrate Pest Control Handbook

d. Reducing the concentration of active ingredient concentration in the bait and requiring the baiting and post-baiting procedures in b and c above should reduce the risk to the California condor. The risk analysis was based on a number of assumption, however, including the LD_{50} for the condor and a 75 percent "detoxification" factor.

Also, the reproductive effects of compound 1080 are still a matter of concern to the Agency. With a population of approximately 30, the Agency believes more protection than would be provided in a, b, and c above is necessary. The following provision will have an impact on the benefits, in that a more expensive or less efficacious alternative will be required, but the impacts will be mitigated by the seasonal distribution and the existence of national forests in the range of the condor. Without the following provision, the Agency does not believe the benefits of use could outweigh the risk to this endangered species. For the protection of the California condor, then, the Agency proposes adoption of the following label requirement:

Do not use in the Sespe-Sierra range of the California Condor or in that portion of the coastal range south of Monterey County. Do not use in the coastal range north of San Luis Obispo County during the months of August through December.

e. The risk of secondary poisoning of the San Joaquin kit fox can be mitigated through a reduction in the active ingredient concentration of the bait, adoption of baiting and post-baiting procedures, and enforcement of a prohibition of use within one mile of an active kit fox den. Considering the sensitivity of the kit fox to compound 1080, the most important of the mitigation measures is the prohibition provision.

The Agency does not have sufficient information on either the procedures followed in conducting a kit fox search or on the effectiveness of a search to estimate the risk reduction that could result from such a prohibition provision. A total prohibition of use within the range of the kit fox could affect the benefits, since a less efficacious or more expensive alternative would have to be used.

Morrell (1975), in estimating the population of the San Joaquin kit fox, arrive at a mean figure of 10,000 adults, with a maximum of 14,800. Assuming, as he did, two adults per active den, yields an estimated 5,000 to 7,400 active dens. A prohibition on the use of compound 1080 bait within a one-mile radius of each active den could preclude use on approximately 15,000 to 22,800 square miles.

The California Fish and Game Commission has closed portions of Kern, San Luis Obispo, Fresno, Kings, and Monterey Counties to all night hunting and furbearer trapping in an effort to protect the San Joaquin kit fox. This area covers the major portion of the San Joaquin kit fox range, totalling less than 15,000 square miles (the actual figure is not available, but a scale measurement from the description yielded approximately 7,000 square miles). Thus a prohibition of use within the area closed to night hunting should not have any greater impact on the benefits than a prohibition on use within one mile of an active den and would be more easily enforced, thereby improving the risk reduction potential. For the remainder of the kit fox range, the Agency believes current California policy will permit sufficient protection.

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For the protection of the San Joaquin kit fox, then, the Agency proposes the following label requirements:

> Do not use in that portion of the range of the San Joaquin kit fox that has been closed to night hunting by the California Fish and Game Commission. In the remainder of the range, consult the California Fish and Game Commission prior to use.

f. For the protection of the Morro Bay kangaroo rat, the Agency proposes adoption of the following label requirements:

> Do not use in the range of the Morro Bay kangaroo rat, as defined by the United States Fish and Wildlife Service.

g. For the protection of the salt marsh harvest mouse, the Agency proposes adoption of the following label requirement:

> Do not use in the range of the salt marsh harvest mouse, as defined by the United States Fish and Wildlife Service.

2. Rangeland Rodents - prairie dogs

The use of compound 1080 to control prairie dogs, although registered in only one state, accounts for seven percent of all the compound 1080 used annually. If it is cancelled as well as strychnine, only zinc phosphide and gas cartridges would be available. The use of gas cartridges would not decrease the risk to the black-footed ferret and would result in a substantial and probably prohibitive increase in control costs. Zinc phosphide is an adequate alternative, but may not have the consistent efficacy of compound 1080 and may result in a per acre treatment cost almost twice that of compound 1080.

A reduction in the active ingredient concentration and improvements in baiting and post-baiting procedures should reduce the risks to nontargets, with the exception of the black-footed ferret, to a level such that the benefits of use will outweigh the risks. The only method other than cancellation that could provide protection for the black-footed ferret is a pre-control survey. The Agency has discussed the feasibility and effectiveness of a survey with officials from Colorado and the U.S. Fish and Wildlife Service. Apparently a properly conducted survey, performed before each control operation, could greatly reduce the possibility of a ferret poisoning, but would raise the cost of control above that of zinc phosphide. The Agency does not have sufficient information at this time, however, to prescribe the details of a survey or to quantify the reduction in risk to the ferret.

For this use, then, the Agency proposes the following modifications:

a. Standardize bait concentration at a maximum of 0.02 percent active ingredient at a dosage of one teaspoon per burrow spread over a three square feet area.

b. Standardize baiting and post-baiting procedures in the same manner as proposed for "Rangeland Rodents - Ground Squirrels."

c. Restrict use to governmental agencies or persons under the direct supervision of members of governmental agencies.

d. Allow the use of compound 1080 in a prairie dog town only if a precontrol survey, conducted in accordance with a protocol approved by EPA, in consultation with USFWS, does not indicate the presence or possible presence of a black-footed ferret.

3. Rangeland Rodents - other rodents

The Agency has no evidence of a potential for substantial risks to nontarget animals from the use of compound 1080 to control pocket gophers. For this use, then, the Agency proposes to take no action.

The Agency proposes the cancellation of the registrations and denial of applications for the control of chipmunks, cotton rats, deer mice, kangaroo rats, and meadow mice on rangeland. These uses potentially endanger nontarget animals and safer alternatives are available for all uses. Because of the low use, because it is currently not being used to control three of the pests (registered only in Nevada), and because of the availability of efficacious, economically viable alternatives, the impact on overall benefits is expected to be minor.

4. Cropland Rodents - ground squirrels

The proposed action for this use is the same as for ground squirrels on rangelands, i.e., modification of the terms and conditions of registration. In addition to the proposed standardization of the bait active ingredient concentration, standardizations of baiting and post-baiting procedures, and the protection of the California condor, San Joaquin kit fox, Morro Bay kangaroo rat, and salt marsh harvest mouse, the Agency believes protective measures are necessary if compound 1080 is used in the range of the Aleutian Canada goose.

The Agency does not have sufficient risk information to warrant prohibition in the entire California range. The period of ground squirrel baiting does not generally coincide with the time that the Aleutian Canada goose is in California. The California Department of Fish and Game has closed three areas to hunting of all Canada geese in order to protect the Aleutian Canada geese. These areas are the major feeding areas and winter residence areas of the Aleutian Canada goose and are the area where the potential for exposure of compound 1080 to the goose would be the highest.

Very little, if any, ground squirrel baiting of croplands is done during the months that the Aleutian Canada goose is in California. Generally, the potential risk to the goose occurs when compound 1080 is used in wetland areas in the migratory range of the goose. The Agency believes that it is possible to virtually eliminate the risks to the Aleutian Canada goose without affecting the benefits. The Agency proposes the prohibition of the use of compound 1080 from September 1 to April 30 for the control of ground squirrels on croplands within the areas closed by the California Department of Fish and Game to the hunting of Canada Geese. Additionally, any baiting for ground squirrels in the wetlands areas of Contra Costa, San Joaquin, Solana and Yolo Counties from September 1 to April 30 would be permitted only if bait stations are used in accordance with the California Vertebrate Control Handbook.

5. Cropland Rodents - prairie dogs

The proposed action, and rationale, for this use is the same as for prairie dogs on rangeland, i.e., modification of the terms and conditions of registration (see page 94).

6. Cropland Rodents - other rodents

The Agency has no evidence of a potential for substantial risks to nontarget animals from the use of compound 1080 to control pocket gophers. For this use then, the Agency proposes adoption of the no action alternative.

The Agency proposes cancellation of the registrations and denial of applications for the control of Norway rats, cotton rats, and wood rats on croplands. The amount of compound 1080 used to control these three rodents is not quantifiable, and alternatives that are of less risk are available for all three. No impacts on benefits are anticipated.

For meadow mouse control on croplands, the Agency is proposing modification of the terms and conditions of registration. Since this use accounts for the majority of the compound 1080 used on croplands, cancellation could result in locally severe impacts on benefits because of the increased cost of using zinc phosphide. Also, risk reduction measures are available that enable the benefits of use to outweigh the risks. The modifications proposed for meadow mouse control on croplands are:

1. Standardize the bait active ingredient concentration at 0.02 percent and a dosage of one tablespoon for hand baiting or four to five pounds per acre for aerial baiting.
2. Standardize baiting and post-baiting procedures for hand and aerial application in accordance with the proposed action under "Rangeland rodents - ground squirrels." (see page 92)
3. Prohibit use in the range of the Aleutian Canada goose in accordance with the proposed action under "Cropland rodents - ground squirrels." (see page 95)

7. Rodents on Nonagricultural Sites

For the use of compound 1080 to control Norway rats, roof rats, and house mice in and around buildings and ships, the Agency proposes adoption of the no action alternative. A true antidote to compound 1080 poisoning is not available. However, the records of accidents since 1950 and the improvement of the instructions for use of the federally registered commensal rodent control product are evidence that exposure of humans and pets from this use of compound 1080 is highly unlikely.

The Agency has no evidence of a potential for substantial risks to nontarget animals from the use of compound 1080 to control pocket gophers. For this use then, the Agency proposes adoption of the no action alternative.

For the control of chipmunks, cotton rats, kangaroo rats, wood rats, Norway rats, and deer mice on nonagricultural sites, the Agency proposes cancellation. These uses potentially endanger nontarget animals and safer alternatives are available.

The Agency has concluded that the benefits of the use of compound 1080 to control ground squirrels on ditch banks, levees, canals and earthen dams will outweigh the risks if modifications of the terms and conditions of registration are adopted. These are:

1. Standardization of the active ingredient concentration and baiting and post-baiting procedures in accordance with the proposed action and rationale under "Rangeland Rodents - ground squirrels" (see page 89).
2. Prohibit use in the range of the Aleutian Canada goose in accordance with the proposed action and rationale under "Cropland rodents - ground squirrels." (see page 95)

E. Summary

For each use of compound 1080 to control rodents, the Agency has proposed either no action, cancellation, or modification of the terms and conditions of registration. This section summarizes these proposed actions.

For rangeland and pasture uses, the proposed action for each pest is:

ground squirrels - modification of the terms and conditions of registration
prairie dogs - modification of the terms and conditions of registration
pocket gophers - no action
chipmunks - denial of applications
cotton rats - denial of applications
deer mice - denial of applications
kangaroo rats - denial of applications
meadow mice - denial of applications

For cropland uses, the proposed action for each pest is:

ground squirrels - modification of the terms and conditions of registration
prairie dogs - modification of terms and conditions of registration
meadow mice - modification of the terms and conditions of registration
pocket gophers - no action
Norway rats - denial of applications
cotton rats - denial of applications
wood rats - denial of applications

For use in and around buildings and ships, the proposed action for each pest is:

Norway rats - no action
roof rats - no action
house mice - no action

For other nonagricultural site uses, the proposed action for each pest is:

ground squirrels (on ditch banks, levees, canals, and earthen dams) - modification of the terms and conditions of registration
chipmunks - denial of applications
cotton rats - denial of applications
Norway rats - denial of applications
Kangaroo rats - denial of applications
wood rats - denial of applications
deer mice - denial of applications
meadow mice - denial of applications
pocket gophers - no action

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